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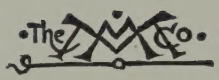
IN DISEASES OF THE EYE, EAR, NOSE AND THROAT



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PHYSICAL THERAPY

IN DISEASES OF THE

EYE, EAR, NOSE AND THROAT

With Chapters on Some Borderline Affections

BY

ABRAHAM R. HOLLENDER, M.D.

ATTENDING OTOLARYNGOLOGIST, AMERICAN HOSPITAL OF CHICAGO,
EDITOR, ARCHIVES OF PHYSICAL THERAPY, X-RAY, RADIUM

AND

MAURICE H. COTTLE, M.D.

ATTENDING OTOLARYNGOLOGIST,
ILLINOIS MASONIC HOSPITAL AT CHICAGO

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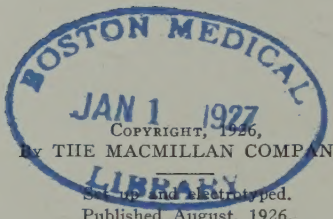

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TO

DISRAELI KOBAK, M.D.

PRESIDENT ELECT, AMERICAN COLLEGE OF PHYSICAL THERAPY
AND ATTENDING PHYSIOTHERAPIST, COOK COUNTY HOSPITAL,
CHICAGO

AS AN EXPRESSION OF APPRECIATION FOR HIS SERVICES
TO SCIENTIFIC PHYSICAL THERAPY

RESPECTFULLY INSCRIBED BY
THE AUTHORS.

PREFACE

The rapid advances in scientific physiotherapy, which have enriched general medicine and surgery to an undreamed of extent, have been forcibly brought to the attention of the medical profession of the entire civilized world through the extraordinary opportunities for concrete demonstration presented by the World War.

Even in the United States, long reputed for its professional conservatism and staunch adherence to classic doctrines, physical therapy is fast gaining official recognition as a legitimate and valuable discipline.

In no one of the surgical specialties is there a greater need for more effective methods of treatment than in ophthalmology and in oto-rhino-laryngology, and in these physical therapy has opened a new field for fruitful research.

The present volume is an earnest attempt to systematize and classify the available material, and to invite attention to the unlimited therapeutic possibilities in these particular fields.

It is scarcely necessary to point out that physical therapy should not be looked upon as a new or special system of therapy in eye, ear, nose and throat practice, but as a legitimate part of our therapeutic armamentarium, to be employed in addition to recognized surgical and medicinal measures.

The authors have purposely avoided burdening the volume with theoretic matter, stressing the clinical aspect as of more practical value to the practitioner.

We desire to express our acknowledgment of indebtedness to Dr. Joseph Gale for assistance in our experimental work, to Dr. Maximilian Kern for suggestions in endocrinology, and to Dr. Israel L. Sherry—all of Chicago—for assistance in numerous ways.

The authors are deeply indebted to the publishers for having spared no expense in making this book mechanically attractive.

A. R. H.
M. H. C.

30 No. Michigan Avenue,
Chicago, June, 1926.

INTRODUCTION

BY

FRANK J. NOVAK, JR., M.D.

Formerly Attending Otolaryngologist,
Cook County Hospital, Chicago.

The brilliant results obtained with physical therapy in a large number of general internal and surgical diseases have stimulated many progressive otolaryngologists and ophthalmologists to employ physical agents for the relief and cure of certain pathologic processes coming under their observation.

Although this is a comparatively recent experiment, sufficient clinical experience has been accumulated to justify the authors to present their own findings, as well as those of other workers, in a systematic manner, for the purpose of establishing physical therapy in otolaryngology and ophthalmology on a sound scientific footing.

Both the specialist and the general practitioner, however, should understand that there are still a number of problems which have not been solved satisfactorily in a strictly scientific sense. Accordingly, one will find, here and there, empiric experiences, always emphasizing that the newer physical therapy is neither a panacea, nor a new therapeutic system to replace the classic treatment with drugs and surgery.

Many specialists have always practiced physical therapy in some form or other. Who has not recommended

heat for inflammation, and who has not advised sunshine in tuberculosis? But as regards electrical and other physical agents,—these up to recently were left all too often to charlatans. We have not only wrested from the pretenders in medicine their monopoly on physical agents, but have destroyed their unwarranted therapeutic pretensions, so that, to-day, physical therapy is a recognized department of ethical medicine.

European universities have long since appreciated the scientific and practical value of physical measures, and have fostered this branch of therapeutics in lecture halls and clinics. American institutions and bodies of learning have been rather slow in according this discipline the recognition it merits, but as the clinical results of the pathfinders are accumulating, and as the products of research are becoming public, physical therapy, and more particularly electro-physical therapy, is being more and more appreciated in the United States, not only in general medicine, but in all recognized specialties.

It is believed that a systematic exposition of the experiences of reliable observers with physical therapy in the affections under consideration, will serve as a guide to such practitioners who earnestly desire to afford their patients the benefits to be derived from the employment of a number of physical agents.

Fortunately for all concerned, the technique is comparatively simple and easily acquired, provided one is familiar with the dosage of the energies utilized. Physiotherapeutic dosage implies intensity of energy, duration and frequency of administration.

The authors do not desire to be understood that hard and fast rules of procedure can now be laid down. As in all other methods, individualization is the keynote to

success, and each individual practitioner must appreciate the basic principles involved, utilize the common experiences of others, and develop a certain initiative in the selection of suitable remedies and in the manner of their use. The charge that this has a certain empiric fundament is not unjustified, but empiricism is a recognized means toward scientific attainment.

To illustrate our meaning we need but recall that for a long time the effectiveness of quinine in malaria or mercury in syphilis was known only empirically. Yet medical science treasured these agencies and looked forward to the establishment of their rationale.

In physical therapy we may not always be able to explain with exactitude why an agent proves curative in a certain disease or class of diseases, but we have the unmistakable evidence of permanent relief, and this must suffice for the present, at least until by physiologic and pathologic researches of the laboratory, its explanation will be available.

It has already been pointed out that physical therapy does not replace the classic methods of treatment. We, however, may claim for it that it is a valuable and essential adjunct of modern therapy. The *ideal* aims to produce speedy, complete and pleasant cures often find realization in the added use of electrotherapy for many affections. The duration of heretofore long drawn-out diseases is shortened to a considerable extent, the treatment itself is rendered more effective and pleasant, and often is productive of rapid symptomatic relief, and permanent *restitutio ad integrum.*

This is an outline of what can be expected at the present time from electro-physical therapy. Earnest efforts on the part of enthusiastic workers will demon-

strate to themselves and to their clientèle, that modern science can no longer ignore the beneficial therapeutic effects of some physical measures, without detriment to our own professional interests, and to the interests of those who confide their physical misfortunes to our keeping.

This, it is believed, has been fully demonstrated in the present volume, and the writer of these lines bespeaks for it a warm reception by our profession.

Fata sua habent libelli! It is hoped that this work will be followed in the not too distant future by other editions, greatly enlarged by additional experiences gained in untrodden fields.

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PART ONE

ELECTRO-PHYSICAL AGENTS

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CHAPTER I

THE GALVANIC CURRENT

The galvanic, or, as it is often referred to, constant current, is of special interest because it has a wide range of therapeutic usefulness in ophthalmology and oto-laryngology. Of all electric currents and energies used in the medical sciences, it is doubtless the simplest in principle, and its application is available through a comparatively inexpensive apparatus.

We deem it of great importance to be familiar with the character and properties of this current before studying its effects on the human body, and we shall, therefore, present all that is needed for our practical purposes.

No doubt every one has seen a simple sal-ammoniac cell, such as is used by many householders to furnish the electric energy to ring the doorbell. This cell represents a unit furnishing the galvanic current.

Fig. 1 shows such a cell diagrammatically. It consists of a simple glass jar, containing a solution of dilute sulphuric acid, or sal-ammoniac, a rod of zinc (marked "Z" in the diagram), and a plate of carbon (marked "C" in the diagram), the two so-called "plates" being placed in a manner not to touch each other, each also being provided with a short, thin, wire. It will be noted that the wire in contact with the carbon plate has a plus (+) mark, which should be read "positive"; while the wire attached to the zinc plate is marked with a minus (—)

sign, which should be read "negative." The illustration also shows an arrow which indicates the direction of the electric current from the cell.

The current is produced by a chemical action which takes place in the cell.[1] At the zinc plate oxygen is developed, and at the carbon plate hydrogen is constantly developed, at least while the plates remain fairly intact, for the chemical action disintegrates the plates, and the cell, thereby, becomes gradually "exhausted."

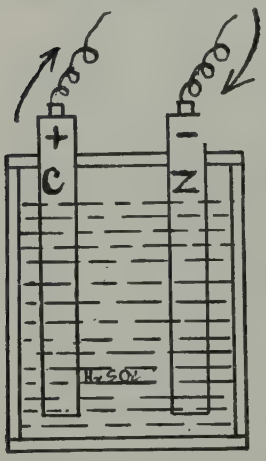


FIG. 1.—Diagram of wet cell.

If the two wires of an active cell are brought close together and the tongue is placed to the tips or ends of the wires, one will experience a slight burning sensation. The tongue acts partly as a body offering resistance to the flow of the electric current and partly connects the two loose wires, thereby "closing the circuit" of the current, for the current flows from the carbon plate or positive pole, to the zinc plate or negative pole. The human tongue reveals that the sensation is not equal at the two places of contact and that the negative pole or wire is distinctly more irritable. This demonstrates "polarity" in the galvanic current, a characteristic which, as we shall see, is of great importance in the therapeutic application of this current.

It required the moist and sensitive human tongue to

[1] Modern physicists are still holding polemic discussions as to whether the electrical energy in a battery cell is primarily one of chemical interaction or whether the chemical action precedes and follows that of an electrical interplay of forces.

feel, as it were, the electric current from a galvanic cell. If we should apply the same wire ends to any part of the body covered by epidermis, we would not feel the current, even if the skin be thoroughly moistened, though it is known that a moist skin is an excellent "conductor" of electric currents. The reason for this is that one cell has not sufficient strength to affect our nervous system sufficiently to be noticeable. To increase the strength we must use a number of cells, and in order to combine their strength as one unit, we must connect the cells "in series," a term illustrated in Fig. 2, which shows that the number

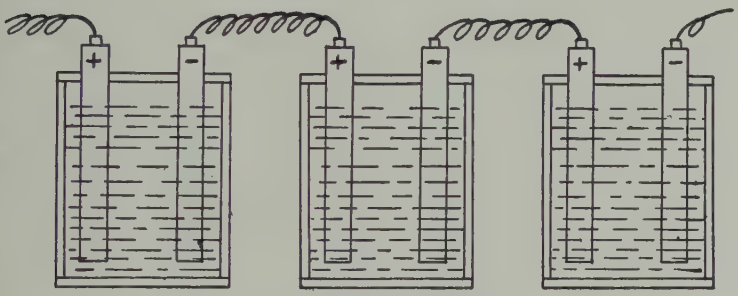


FIG. 2.—Cells in a series.

of cells employed are united as a "battery," by simply connecting the carbon of the first cell to the zinc of the second, the same connection being continued to the last cell. The wires connecting with the zinc plate of the first and the carbon plate of the last cell will now have a comparatively strong constant current. The tongue will receive a very disagreeable, if not hurtful, sensation, and the moistened skin anywhere on the body will now feel the current. The larger the number of cells connected in series, the more intense will be the effect on the human body.

To all intents and purposes a number of simple cells connected in series and two terminal wires represent a galvanic battery or apparatus by means of which the current can be applied wherever desired. If we use insulation to prevent accidental contact of the wires, and if we connect the ends of the wires with sponges or discs or rods—electrodes—shaped to produce better contact with the parts of the body to be treated, we have a working arrangement. But such a battery has certain defects which modern manufacturers have overcome most ingeniously.

To appreciate the advantages of the apparatus described and illustrated below, it is necessary to take a glance at the galvanic batteries in vogue but a few years ago.

Physicians then had "cabinets," the size of an average book-case, on the shelves of which were a number of ordinary sal-ammoniac cells. These cells required frequent attention. The liquid evaporated and fresh solutions of sal-ammoniac had to be added. The zinc plates became disintegrated in time and had to be replaced. Even the carbon plates occasionally required replacement.

The physicians of but two decades ago considered themselves fortunate to have their batteries arranged in such a manner that they did not have to change the wires between the cells every time they desired to use only a limited number of them. This was obtained by having the cells connected with buttons arranged as a circle on the "switchboard," sliding handles connecting these buttons, as desired. If, to illustrate, the operator decided that ten cells would about furnish the strength necessary to obtain a certain therapeutic effect, all he had

to do was to switch the two handles to include the cells desired from the entire battery and apply the electrodes. If it was found that the calculation was wrong and that a larger or smaller number of cells had to be used, the handles on the switchboard were pushed over the circle of buttons as needed. But this operation produced undesirable and often very unpleasant effects, which sensitive patients felt as electric "shocks."

Scientific dosage was out of the question. When one said that he used, let us say, fifteen cells, to obtain a certain effect, such a statement or teaching had only a relative meaning. How long had the cells been used? What make were the cells? What was the strength of the solution of the cells? What size zinc and what size carbon plates were used? Unless one could obtain identical conditions, one was in no position to gage the strength of the current employed.

All this has been overcome to-day by three measures, so that galvanic therapy can be carried out not only with ease and convenience, but above all with scientific precision.

The first of these measures refers to the source of energy. The wet cell has become obsolete and has been replaced by small dry cells which have a fairly long life. A number sufficient for all therapeutic purposes requires only a small box under the switchboard of a portable galvanic battery. The direct street lighting current, while not ideal, furnishes a satisfactory source of energy which can be directly attached to the switchboard. When an alternating current only is available, it must first be transformed into a direct current by a rotary converter.

Every modern switchboard, whether on a portable or stationary apparatus has a simple device—a rheostat—

which enables the operator to control the intensity of the current from zero to full capacity, gradually, that is to say, without "shock" to the patient. There are several makes of rheostats, but their principle is one and the same, namely to interpose resistance between the current and the human body. The simplest form is a circular appliance of graphite provided with a sliding handle.

Lastly, we find on each modern galvanic battery a clock-like device to measure the intensity of the current —a milliamperemeter.

Here it seems proper to interrupt our description to become somewhat familiar with electric energy.

A *volt* [1] is the unit of electromotive force (EMF) necessary to cause one ampere of current to flow against one ohm of resistance. Accordingly, an *ampere* [2] is a unit of electric current afforded by one volt of electromotive force against one ohm of resistance. An *ohm* [3] is a unit of electric resistance presented by a column of mercury one square milliameter in diameter and 106 centimeters in length. (In Britain, a copper wire one millimeter in diameter and 485 meters long, has been accepted to represent one ohm resistance.)

The relation of voltage and resistance to amperage is expressed by the formula, $C = \frac{E}{R}$. In this formula C represents current in amperage, E, difference of potential in volts, and R, resistance in ohms.

The formula could therefore also read:

Number of amperes equals the number of volts divided by the number of ohms.

[1] Named for Alessandro Volta, Italian Physicist, 1745-1827.
[2] Named for André Marie Ampère, French mathematician, 1775-1836.
[3] Named for Georg S. Ohm, German Physicist, 1787-1854.

A milliampere is one-thousandth of one ampere and the milliamperemeter on most galvanic batteries registers up to 150 milliamperes.

Human tissue under certain conditions is an excellent conductor of electric currents, so that even comparatively "weak" currents produce certain physiologic effects. It is interesting to follow Humphris' classification of the three actions of the galvanic current.

1. Its effect in ionic medication or in cataphoresis.
2. Its ionic or galvanic effect in restoring a healthy metabolism to a pathological condition of the body, as in central galvanism; or any part of it, as in rheumatic knee.
3. Its electrolytic or destructive effect to the whole body, as in electrocution, or to any part of it, as in electrolysis for the removal of a mole or superfluous hair.

The literature is replete with terms like phoresis, cataphoresis, electrolysis, ionization, ionic medication, whose definition is neither uniform nor standardized.

It is therefore proper to investigate the actual meaning of the nomenclature. Humphris regards ionic medication and cataphoresis virtually as synonymous, and implies that the galvanic current is capable of forcing chemicals or metallic substances through the unbroken skin or mucous membranes into the deeper tissues.

Faraday has used the term "ion" for the phenomenon observed during the passage of electric currents through conducting solutions, particularly of the migration of the chemical products of decomposition toward the poles. The term *cataphoresis* is the Greek expression for *bearing across,* and is generally used to imply the introduction of suitable medicines through the skin by means of an electric current, which is best explainable by the fact that the "ions" move toward the poles of a galvanic current

because they are charged electrically and thereby develop a tendency to move in the direction of the oppositely charged pole.

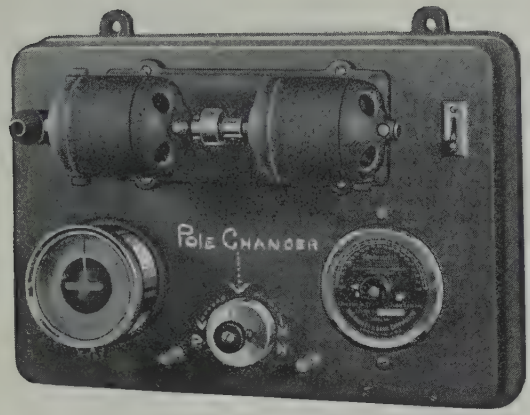
The power of certain electric currents to produce electrochemical decomposition in substances which they traverse, is a property known as *electrolysis.*

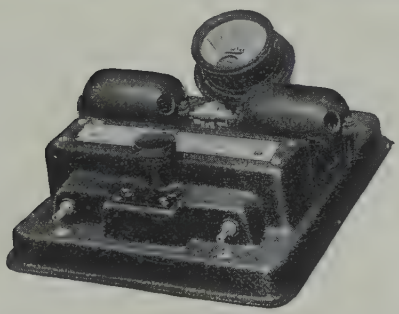
Sufficient has been said to indicate the importance of the direction of the galvanic current from the positive to the negative pole of a cell or battery. This will also have decided clinical importance, for the electrode attached to the positive pole—the anode—produces entirely different effects on animal tissues than the electrode attached to the negative pole—the cathode.

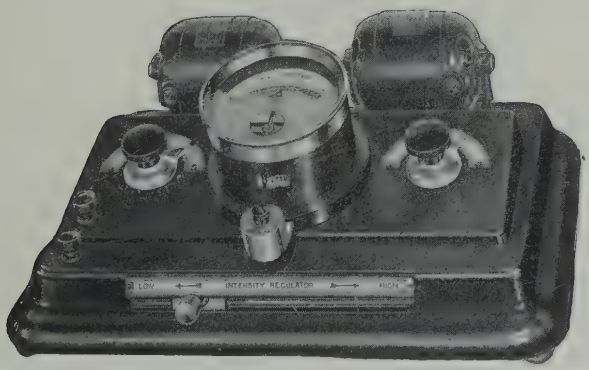
Manufacturers have fully appreciated this significance and have provided modern apparatus with different colored terminal cords to facilitate identification of the polarity. The polarity is usually permanently fixed and is indicated on the binding posts by the letters "P" and "N," (Fig. 3) or the equivalent signs of plus (+) and minus (—). (Figs. 4 and 5.)

The properties of the galvanic current are distinctive from those of the other currents which will be discussed in the following chapters. The various elements have a proven electrical reaction: they are either electro-positive or electro-negative. This can be demonstrated readily upon viable tissue or in the laboratory. By applying the law, "like substances repel and opposites attract one another," to the various elements, the electro-positive elements are repelled from the positive pole; while the electrically charged negative elements are just as promptly repelled from the negative pole.

Thus we can effectively apply and introduce various chemicals or elements into tissue substance. All metals







Figs. 3, 4 and 5.—Modern galvanic apparatus.

are electro-positive and hence can be conveyed or repelled into tissue from the positive pole; all of the halogens and the salicylates are electro-negative and can be introduced into the tissues by the negative pole. Copper can be introduced by the positive pole, a fact which is demonstrable by the bluish stain or deposit on the tissues, while in the case of silver salts, a blackish stain demonstrates the effect.

Iodine, which belongs to the halogens, can be conveyed into living substance from the negative pole only, since it is electro-negative in charge. This is demonstrated by its staining effect upon a starch solution or upon a potato or by laboratory tests on urine. In this connection it is well to remember also that acid radicals are electro-negative, basic radicals, electro-positive. With this in mind, it can be understood that a weak solution of adrenalin can be drawn into tissues by the positive pole. Such a method is undoubtedly superior to topical application of the same drug.

Other polar effects of the galvanic current should be noted. The *positive* pole is acid in reaction and sedative in effect. It hardens and contracts tissue and therefore acts as a vasoconstrictor. It possesses the power of arresting hemorrhage by styptic qualities, dehydrating and drying tissues and allaying inflammation. The *negative* pole is alkaline in reaction, irritant in effect. This pole is capable of softening and relaxing tissue. For this reason it is used to advantage in scar tissue formation, because of its ability to retain and absorb moisture. It is a vasodilator, tending to increase hemorrhage.

It is only during the past decade that the true value of galvanism as a therapeutic agent has been better appreciated. It was formerly used a great deal for certain

diseases, such as optic atrophy and other hopeless conditions, but the reported successes appear to be somewhat exaggerated. There is no doubt, however, that galvanic electricity is of considerable value in many eye affections.

To Leduc, Friel, and others is due the credit for pioneer work in metallic ionization of suppurative processes. This method is appropriate for chronic otorrheas for which no satisfactory treatment has heretofore been known.

For ulceration of mucous membranes, ionization is indeed a valuable addition to our therapeutic armamentarium. We have employed metallic ionization in some intractable cases of seasonal hay-fever with marked nasal symptoms and have found it highly satisfactory in producing relief when other recognized measures had failed.

Ionization is considered of great value also in some nasal affections. Negative galvanism is now used as an adjuvant in the treatment of defective hearing.

Galvanic treatments should as a general rule not be given oftener than two to three times weekly at first, later at longer intervals.

The technic of metallic ionization and galvanotherapy is described in detail in the chapters dealing with the affections for which these procedures are employed.

CHAPTER II

HIGH FREQUENCY CURRENTS—DIATHERMY

High Frequency Currents are alternating currents having a frequency of oscillation which exceed the limit to which muscle tissue will respond. The frequency usually employed in therapy varies from 1-2½ millions per second, and when the current is made to pass through the body, the resistance of the tissues generates heat.

The high frequency apparatus is operated on the current obtained from the city lighting mains. If the latter supply direct current, a rotary converter is necessary to alternate it, because direct current does not lend itself satisfactorily to the production of high frequency currents.

The voltage required is high, therefore, the ordinary 110 volts capacity is inadequate and the machine must be so constructed as to raise this voltage (Fig. 6). This is usually accomplished by a transformer immersed in oil. A secondary transformer raises the number of oscillations to over a million per second by placing condensers and spark gaps in the circuit between the primary and secondary transformers. The condensers induce the electrical charge to discharge its energy across the spark gaps. A spark gap is merely a variable resistance and its function is to force the current back into the condensers and charge them.

Until recently the spark gaps on many of the machines

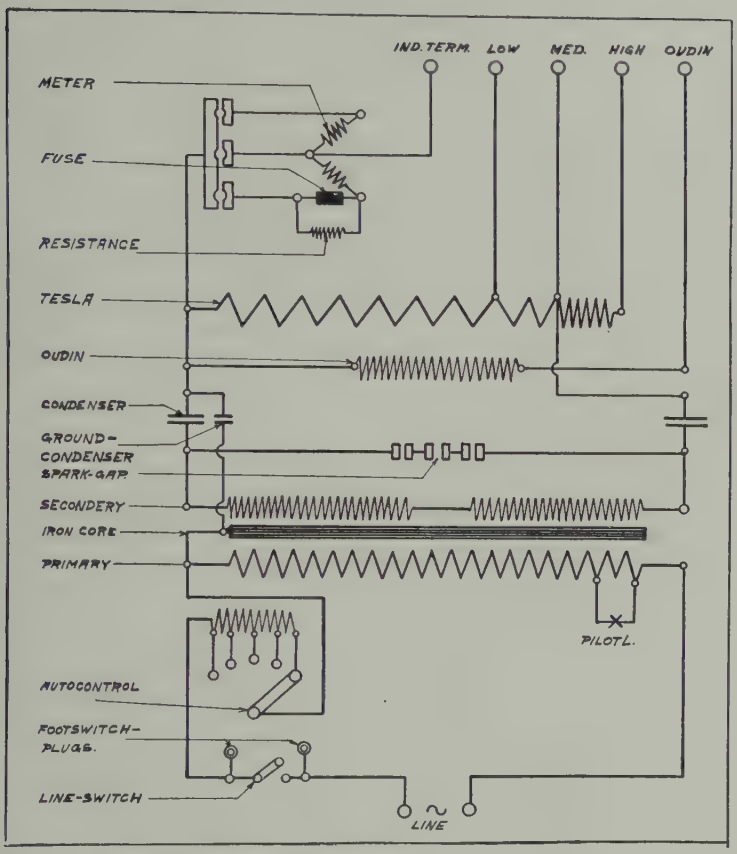


FIG. 6.—Diagram of a portable high frequency unit.

were quite unsatisfactory. In fact, several otherwise good outfits could not perform the work required of them until changes were made in the spark gap arrangement. The Kolischer gap (Fig. 7) is a distinct improvement.

The DeKraft Multiple type which was satisfactory in many ways, developed disadvantages due to the confinement of gases within copper cups and the small

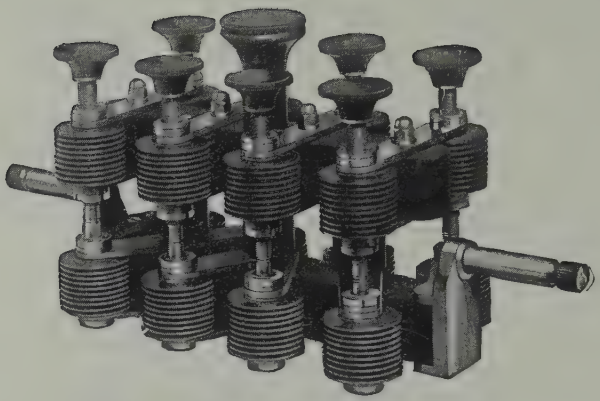


Fig. 7.—Kolischer spark gap (Fischer).

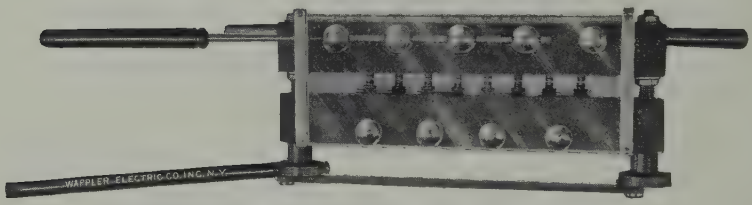


Fig. 8.—Sixteen-surface spark gap (Wappler).

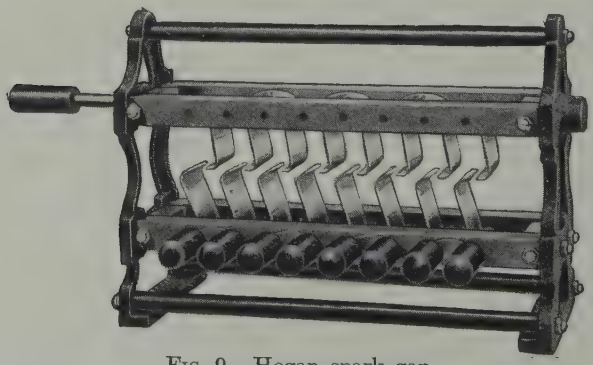


Fig. 9.—Hogan spark gap.

spaces of insulation between sections. These difficulties have been overcome by an entire rearrangement, which still retains the good features of the series of gaps (Fig. 8).

The spark gap illustrated in Fig. 9 is claimed by its manufacturer to possess a precise method of gap regulation. A double advantage is the rapid dissemination of heat by the oscillation of the spark from side to side along the edges of the plates, and the large cooling surface afforded by the plates themselves.

A milliamperemeter (Fig. 10) is used to indicate the relative or total amount of current which passes through the patient. It is well to remember that the degree of heat produced varies inversely as the square of the electrode. If the density of the tissues is constant and the size of the electrodes is not varied, a small increase in current strength will produce a relatively greater rise in temperature. The meter will indicate only a slight rise, but the increased heat in the tissues is relatively greater than the observer would believe from the meter reading.

Fig. 10.—Milliampere meter.

The typical current produced by an apparatus just described is one of low voltage and relatively low frequency. This is a bi-terminal, high frequency current of the D'Arsonval type (so named for Professor D'Arsonval of Paris, its discoverer). It is commonly called diathermy—a word coined by Franz Nagelschmidt—since, as the word implies, it is capable of "heating through" any part of the body.

[1] According to Kobak, the term *"bi-terminal"* is preferred to *"bi-polar,"* because there is no polarity action as in a galvanic current.

The frequency and the voltage may be increased by adding solenoids or wire coils and the current so modified becomes a *mono-terminal* current. Such a current is commonly called Tesla current.

The frequency and the voltage may be raised still further by means of an Oudin resonator, and the current so produced, is of relatively low amperage and is referred to as the Oudin current. This is also mono-terminal, and like the Tesla current, its superficial heating effects are more pronounced than in diathermy.

D'Arsonval, in 1890, was the first to demonstrate the characteristic phenomenon of high frequency currents, namely, a suppression of all muscular contractions. He employed the apparatus of Hertz and produced a current which was of sufficient frequency of oscillation to suppress muscular contraction. In 1893, D'Arsonval published a paper on the physiological action of high frequency currents, in which he gave his deductions, based on experimental work. D'Arsonval found:

1. That the tissues traversed by high frequency currents became less excitable to ordinary excitants.
2. That a manometer placed in the carotid of a dog showed a fall of many centimeters under the influence of high frequency currents.
3. That after the current had been administered for some time, the skin became vascularized and covered with sweat.
4. That the respiratory exchanges showed an increase.
5. That a thermometer did not show any elevation of the ordinary temperature, the extra heat produced being lost by radiation and evaporation.

Turrell makes quite a point of the difference in effects of the high frequency currents derived from the older

styles of apparatus, as compared with the currents of the newer types of diathermy machines. He suggested that it would be less confusing and more explicit, if instead of distinguishing between High Frequency and Diathermy currents, we spoke of the former as High Frequency Currents of Tension, and of the latter as High Frequency Currents of Quantity. Turrell explains this subject further: "With high frequency currents of tension, the voltage may be so high that, in spite of the high frequency of the oscillations, sensation and even contraction may be excited; but with the high frequency currents of quantity (diathermy) the voltage is so much lower and the frequency is so much higher that no sensation is experienced apart from that of heat."

The lack of a satisfactory explanation for the heat, perceived when the current of a high frequency machine is passed through the body, has been felt for many years. It is only of late that research on the electric excitability of muscles has proved that the power of an electric current to stimulate the excitable tissues depends not only on the strength of the current but also on the duration of its flow. It is an accepted fact, also, that the high frequency current is unable to produce any chemical (electrolytic) changes in the tissues. It flows for so short a time in either direction before reversal, that it is unable to impart any movement of the ions in the tissue fluids. The ions therefore do not migrate to the electrodes and therefore cannot give up their electric charges and form new chemical compounds. (Cumberbatch.)

Some interesting data regarding the influence of diathermy on the cardiovascular system have been

advanced by many observers. As this subject is not strictly within the scope of this volume, a detailed account is not presented here.

Cumberbatch cites a report of Cloetta and Waser (*Archiv für Experimentelle Pathologie and Pharmakologie*, June 25, 1914) who showed a rise of one degree Centigrade in the lateral ventricle of a dog after diathermy for ten minutes. The temperature fell to normal in ten minutes after stopping the diathermy.

Several chapters on experimental work conducted by the authors will be found in the appendix. The experiments were carried on to observe the effects of diathermy and other physical agents on various conditions which the ophthalmologist and otolaryngologist are called upon to treat. The animal studies were always supplemented by clinical investigations. It is hoped that the tables, deductions and suggestions for clinical application will be found of some value.

There is still much room left for original work, and experimentation with diathermy in eye, ear, nose and throat diseases merits encouragement.

APPARATUS

There are two types of machines—large office size and portable. A high frequency machine to be adequate to meet the needs of constant usage must be constructed to provide sufficient voltage and milliamperage.

For medical diathermy, especially in eye, ear, nose and throat work, only a comparatively low milliamperage is required. For surgical diathermy, higher milliamperage is necessary because of the destructive effects desired. If a portable outfit will deliver the amount of current essential for depth penetration, it will probably be as

satisfactory as the larger office type of machine, although the latter is to be preferred because of its greater flexibility and dependability.

Proper care of a high frequency machine and rotary converter is of the utmost importance. Frequent inspections and oiling of the parts will help to avoid interruptions in service.

Every high frequency machine is furnished by the manufacturer with a number of stock electrodes. Some of these are of little use to the eye, ear, nose and throat specialist. Progress made during the past few years with electrical apparatus, have made possible the electrodes required in the various specialties. Suitable electrodes, at least for temporary purposes, can always be improvised in a short time. The physician should familiarize himself with the making of improvised electrodes out of the tin foil supplied with all outfits. Whenever possible, however, perfected electrodes for special indications should be secured, as they will give better clinical results.

Diathermy, or *diathermia,* as it is frequently termed, has many advantages over the usual heating agents. The heat is conversive in nature and is created within the tissue structures. It is therefore endogenous. The heat produced by a hot water bottle is conductive while that produced by radiant light is convective. Both of the latter two forms are inferior, because their exogenous nature rarely permits penetration deeper than the subcutaneous structures. The heat thus generated is immediately taken up by the subcutaneous circulation and carried to distal parts. Conversive heat within the part is the most potent factor in production of the hyperemia which results after diathermy administration. The rise in temperature is always greatest in the path between

the electrodes, the point of greatest heat intensity always being near the smaller one. For the heat varies directly as the square of the electrode and inversely as the size of the electrode.

MEDICAL DIATHERMY

Medical diathermy is of great use in diseases of the eye, ear, nose and nasal accessory sinuses. The larynx also is occasionally treated with this agent. Not infrequently, medical diathermy is used for throat affections and for various conditions of the face which come under the care of the nose specialist.

For all treatments in eye, ear, nose and throat work, some principles of procedure are more or less constant. These are:

1. Preparation of the machine.
2. Choice and preparation of electrodes.
3. Duration and frequency of treatments.
4. Sequence of other physical agents.

The preparation of the machine embraces a knowledge of its working order at the time it is to be used. The switches must be easily accessible and the line current under control. With the levers and rheostat in position, the spark gap is closed and the cords are attached to their appropriate binding posts.

Electrodes, suitable for the part to be treated, are selected with great care. Metal electrodes are best. These should be large enough to more than cover the area to be treated, and sufficiently flexible to be adaptable to the parts. The indifferent electrode should be larger than the active one. A heavy warm soap lather is applied liberally over the electrodes. Both the active and the indifferent electrodes should be approximated firmly to

the skin surfaces, using firm pressure to obtain good contact. If cotton webbing or rubber bandage is used to hold the electrodes in place, these materials should be of good quality, possessing sufficient elasticity to hold firmly in place the electrodes necessary for the treatment. The electrodes properly placed, the cords are attached to the binding posts and, after a complete inspection of all parts, the current is turned on.

The spark gap is opened gradually and the intensity of the current is slowly increased. It should take several minutes to raise the current to the maximum intensity desired, as long as five minutes being necessary if a bony part is to be treated, or the effects to be conducted through a bony wall. This refers especially to our method of treating such a condition as "impaired hearing."

The amperage of the current to be used is usually estimated by allowing 75 to 100 milliamperes for every square inch of the active electrode. An average milliamperage for eye, ear and nose cases is 300, due to the small depth penetration needed, and the resistance of the structures usually treated.

Medical diathermy treatments, to be thoroughly effective, should last not less than thirty minutes. Forty minutes are none too long, if one is to allow time for maximum intensity of the current. Short treatments, as frequently advocated, are worthless and often bring about condemnation of a method, when the fault lies with the operator. Frequency of administration, too, is an important factor. It is quite proper to say that for most conditions, the more frequent the treatments, the quicker and better will be the results. Medical diathermy should be administered not less than three to four times weekly. This rule applies especially to chronic cases.

Diathermy is usually preceded or followed by some other electro-physical agent, which should be decided upon when a plan of treatment is outlined. In defective hearing, for example, negative galvanism is employed by us after the administration of the diathermy. Some, however, prefer the constant rythmic current. Whichever agent is selected, its use should be based on clinical or experimental study. Diathermy is much more efficacious, in some conditions, when supplemented by other measures, than when used alone.

Practically all the foregoing is also applicable in considering mono-terminal currents. It must be repeated that because of the higher frequency and higher voltage the heat produced is more superficial and cannot be localized or directed into the deeper tissues. The body acts as a condenser to these currents which flow in and out very readily. They are thus liable to be easily diffused and dispersed and are not easily controlled. For medical purposes their application is usually effected with vacuum and non-vacuum electrodes or with auto-condensation pads. The former are made of glass and are designed to fit the part to be treated. They serve as condensers while the body acts as a "ground," the area of contact being the place of resistance and therefore the area of heat generation. Non-vacuum electrodes are more efficient than the vacuum kind because of their greater condenser properties. (Fig. 11.)

The autocondensation pad is best used on a low couch and is constructed with metal places and insulating materials and covered in such a fashion that an individual may rest comfortably on it. When the pad is connected to a bi-terminal current, the patient lying on it becomes electrically charged and acts as a condenser. If he holds

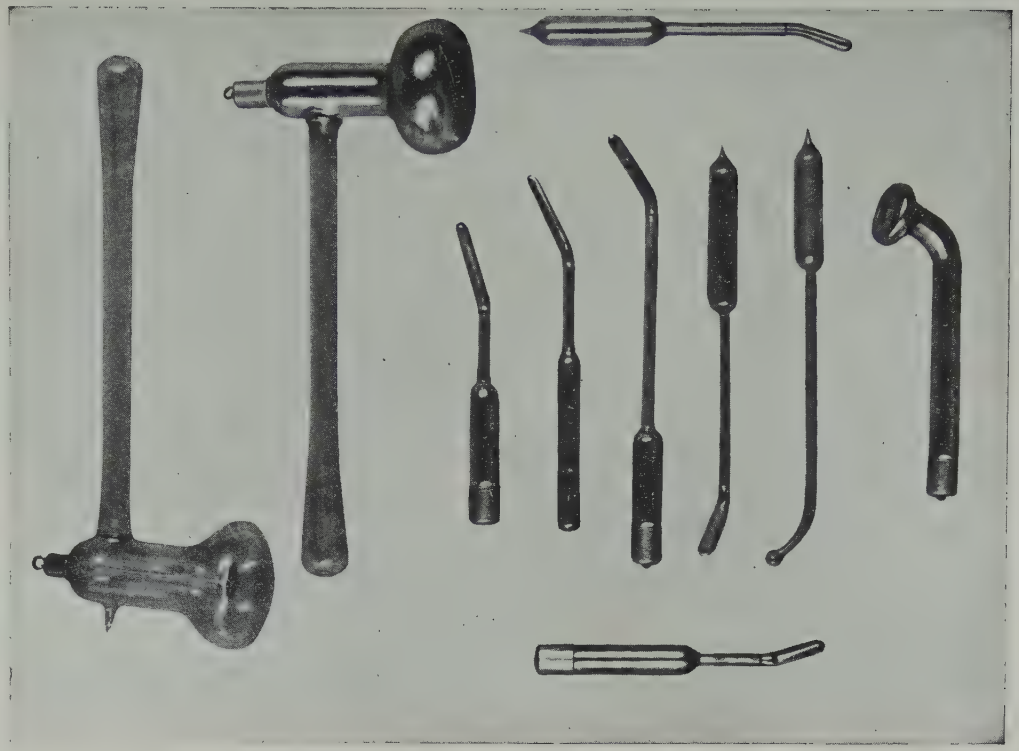


Fig. 11.—Vacuum and non-vacuum electrodes.

in his hand a metal cylinder (Fig. 12) which is connected to the milliamperemeter, a warming of the whole body will be produced with a current of 600-1000 ma. Grounding, however, may be brought about by the operator touching the patient with his fingers, or with an electrode, so that the heat produced will be felt only at the area of contact.

Fig. 12.—Autocondensation. Patient holding metal cylinder

Eye.—Medical diathermy may be used for eye conditions by means of mono-terminal and bi-terminal currents. For the former, a layer of cotton is saturated in a warm saline solution and placed over the eye to be treated. A non-vacuum electrode is then closely applied to the moist cotton. The electrode is attached to the Oudin or Tesla terminal and the current is turned on. To treat both eyes at once, a binocular electrode (Fig. 13) is used. The use of vacuum electrodes has been advised by some earlier writers. This type of treatment is usually given with the patient sitting in a chair or reclining on a couch, and is classified as indirect diathermy. Still another method is to place the patient on an autoconden-

sation pad which is connected to the Oudin terminal. The operator then uses the fingers (one, two or three, as is necessary) to "draw off" the heat from the eyes, the

Fig. 13.—High frequency application with binocular non-vacuum eltctrode.

patient acting as condenser. These technics are adequate where superficial effects are desired, as in treating lesions of the lids, but for deeper thermo-generation, direct diathermy employing the biterminal technic is the method of choice.

The active electrode is approximated to the lids over the ball of the eye. A metal contact, such as is provided for in our specially devised apparatus (Fig. 14) has proved very efficient. Thorough moistening of this electrode and moderate pressure are essential, else discomfort and sparking occur, rendering the treatment objectionable. The larger indifferent electrode is placed on the nape of the neck, held steady and fastened from the

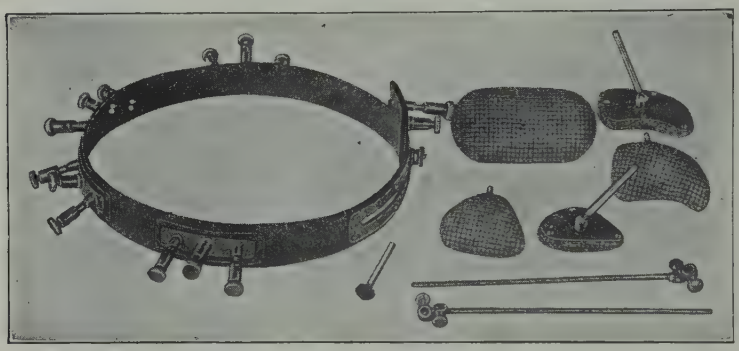


Fig. 14.—Head apparatus and special electrodes for eyes, ears, sinuses, etc.

same apparatus, or with a towel or elastic bandage. The electrodes are then connected by cords to the high voltage arrangement of the diathermy machine and the current is gradually turned on. During the next five minutes, the current is slowly increased to a point just within heat tolerance, which will usually be 250 to 350 ma. This current is maintained for twenty minutes and then slowly turned off.

Interposition of pads of felt or moist cotton between the electrodes and the eye (or any other part) may result in the occurrence of hot spots and sparking, and always decreases the efficiency of the treatment. By means of

the newer and perfected electrodes, direct contact is easily secured. Treatment of the eyes through the tissues lateral to the orbit is very unsatisfactory for the reason that the interposing bony structures are more difficult to penetrate than the anterior soft structure of the eyeball.

Ear.—For purposes of diathermy treatment, the ear may be divided into lateral and medial divisions, the tympanic membrane being the dividing line.

Lateral Portion: The Oudin current is attached to a special vacuum or non-vacuum ear electrode which is introduced into the external auditory canal. The current is turned on and a point of tolerance reached.

Fig. 15.—Sponge-tipped electrode for ear.

For treatment of the tympanic membrane itself, the bi-terminal current is more exact. A sponge-tipped electrode (Figs. 15 and 15A), or a moist cotton pledget is placed in contact with the drum membrane. The indifferent electrode is firmly adjusted to the opposite side of the head between the external canthus of the eye and the anterior border of the ear. The current is turned on; it should rarely exceed 50-75 milliam-

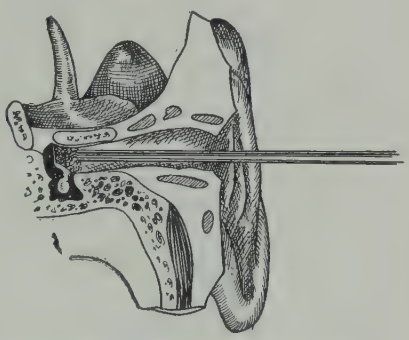


Fig. 15A.—Electrode in ear canal in proximity to tympanum.

peres, as this produces a local temperature of 105 degrees F., or more, and is frequently sufficient to stimulate the labyrinth to the production of nystagmus, and even to nausea and vomiting. Thus the method may be used for labyrinth function testing.

Medial Portion: Treatment of diseases of the middle and inner ears is best accomplished by applying an electrode over the mastoid process close to the posterior and superior attachments of the pinna. The indifferent electrode is placed on the opposite side of the head as described above, but is fixed as far forward as possible. Firm pressure is applied to both electrodes and these are attached to the apparatus. As usual, the current is turned on slowly up to toleration. Not more than 300 to 500 ma. should be used. The total time of treatment should be 30 minutes.

Linn, in the treatment of middle ear disease, combines the canal and mastoid electrodes, using them simultaneously on both sides. Sampson and others use sheets of block tin cut to fit about the ears with a tongue-shaped flap over the tragus, the flap being pressed into the external auditory canal, which previously has been packed with moist saline cotton. If both ears are treated at the same time, the electrodes are of equal size. If one ear only is to be treated, a similar, but much larger, electrode is used as the indifferent one.

Nose and Nasal Accessory Sinuses.—Diathermy is here classified into extra- and intranasal.

Extra-nasal: Vacuum and non-vacuum electrodes have been used for many years in sinus disease. The application is made directly over the sinus and may be stationary or mobile. The electrode in the latter is

moved or slid over the treated area while the current is on.

Bi-terminal diathermy of the sinuses has great heat penetrating power. It is most simply applied by the authors' head apparatus as for the ear and eye, the active electrodes being specially designed for antrum and frontal sinus treatments. The indifferent electrode is applied to the nape of the neck. Treatment of the sphenoid region externally can be attempted by using large electrodes on both sides of the face, with their centers on a level with the sinus.

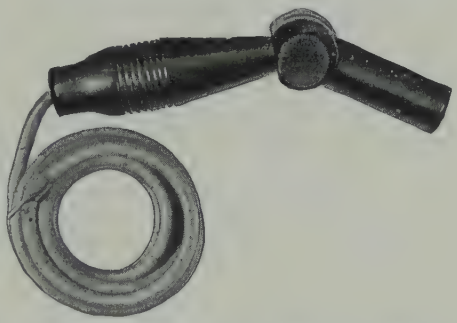


Fig. 16.—Adjustable holder for vacuum and non-vacuum electrodes (authors' design).

A short non-vacuum electrode in an adjustable holder (Fig. 16) attached to an Oudin or Tesla current is the best method for using diathermy intranasally (Fig. 16A). One must proceed slowly, determining meanwhile whether there is any sparking extra-nasally, and how much current the patient can tolerate. The tolerance can be slowly increased with time and patience. Treatment should be directed to all the surfaces of the nasal mucous membrane.

This type of treatment is indicated for diseases of the mucous membrane, and the ethmoid and sphenoid sinuses, and also as a supplement to extra-nasal diathermy.

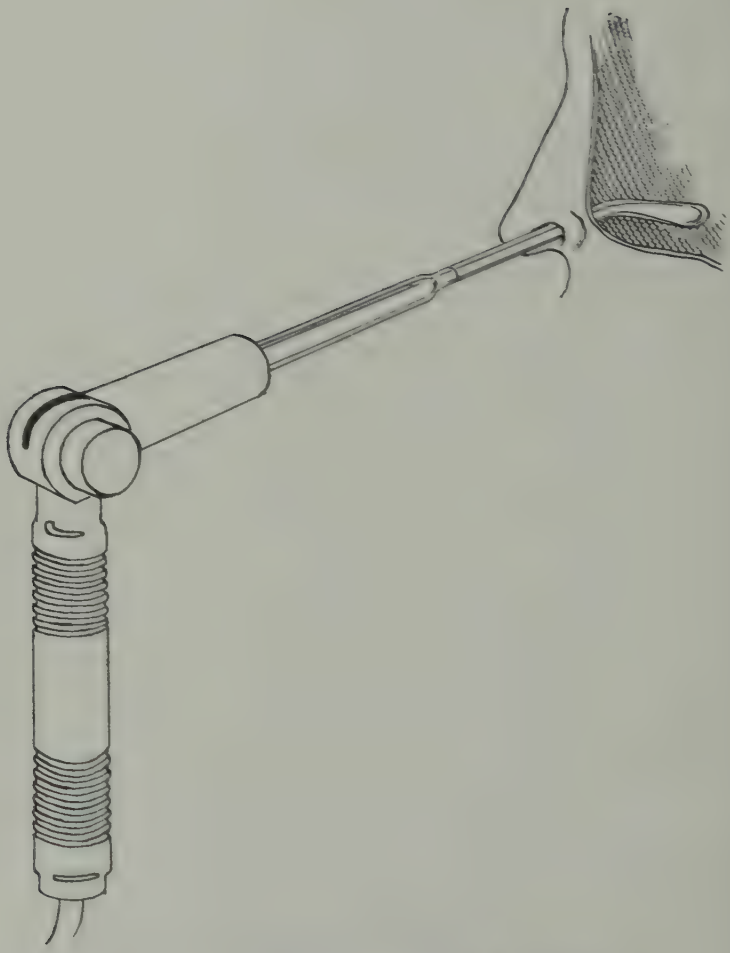


Fig. 16A.—Non-vacuum electrode in position for intranasal diathermy.

Larynx.—This region may be treated by applying a non-vacuum electrode directly over the larynx.

Perhaps the use of a biterminal current with the active electrode on one side of the larynx and the indifferent one on the back of the neck is more effective. Small but equal electrodes, placed on each side of the larynx, may also be employed.

Face and Neck.—Application of diathermy to muscles, nerves, glands, and joints of the face and neck is easily accomplished with a biterminal current. The active electrode is firmly applied over the area to be treated, while the indifferent one is placed diametrically opposite. Diathermy has been suggested for subacute tonsillitis associated with pain, and is administered through an active electrode placed below the angle of the jaw (Fig. 17). The use of non-vacuum electrodes is usually gratifying for the treatment of superficial lesions of the face, such as the neuralgias.

SURGICAL DIATHERMY

By surgical diathermy is understood a high frequency current of sufficient intensity to raise the temperature of tissues beyond physiological limits and thereby destroying them. Surgical diathermy includes such effects as: *electrocoagulation, electrodesiccation,* and *fulguration.* Electrocoagulation implies tissue coagulation, "not burning, charring, nor incineration." Desiccation is a process of surface tissue dehydration. Fulguration is a sparking of tissues with subsequent carbonization.

The heat which these three methods produce is generated by the resistance of the tissues to the current and is of greatest intensity at the smaller or active electrode, where the lines of electrical force are concentrated.

Fig. 17.—Method of treating subacute tonsillitis with active electrode below the angle of the jaw.

Electrocoagulation is a bi-terminal method; electro-desiccation, a mono-terminal method. Electrocoagulation is employed chiefly for large growths, not easily accessible and desiccation for surface growths of the skin and superficial tissues. Electrocoagulation is preferred

Fig. 18.—Electrode set for surgical diathermy.

by some operators at all times, irrespective of the size or location of the tumor.

General anesthesia is usually necessary for extensive work, although local anesthesia is frequently employed for all sorts of operations. Ether is dangerous for obvi-

ous reasons, but electrocoagulation may be performed when proper precautions are taken with this anesthetic. The usual procedure is to put the patient to sleep and then remove the ether can and mask from the room. When such measures are taken, no dangerous consequences are to be feared. Chloroform is the general anesthetic of choice for surgical diathermy as it has been employed without mishap in thousands of operations. For local analgesia, novocain, one percent, is preferred by many surgeons.

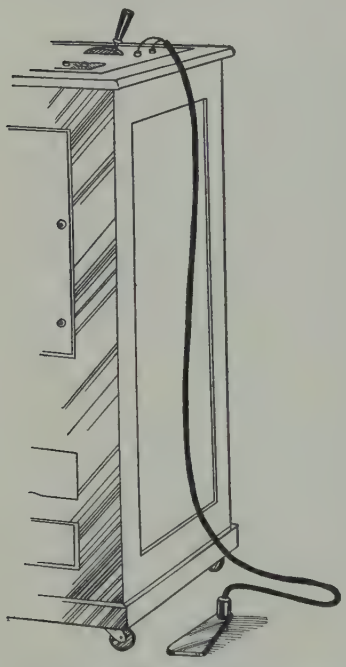


Fig. 19.—Foot switch in circuit for control of current by operator.

The active electrode is either a needle, metal ball, button or knife blade (Fig. 18), in a suitable insulated holder. The indifferent electrode, a large metal (lead or tin foil) pad, is applied to the patient's back or abdomen. Soap lather, made of a special compound soap paste or with green soap, or large wet gauze pads, are used on the skin before the indifferent electrode is applied. The latter is held in place by means of suitable muslin or elastic bandages. These precautions must be taken to prevent burning of the skin beneath the electrode.

While the electrodes are being adjusted and connected to the diathermy apparatus, a foot switch (Fig. 19) is introduced into the circuit so that the operator may easily control the current. The milliamperage employed will vary from 300 ma. for surface neoplasms to 2500 ma. (2½ amperes) for deeper or more extensive growths. It must be remembered that actual coagulation in tissues extends a distance from the electrode equal to the diameter of the electrode. Furthermore, coagulation has been accomplished when bubbling occurs, and at this point the current is turned off. Sparking and charring should not occur.

The type of active electrode will depend on the part to be coagulated. Needles answer well when it is desired to "wall off" a part, while button or ball electrodes will ideally produce coagulation of the growth itself. Coagulation should always extend well beyond the area treated, often into normal tissues.

Electrocoagulation usually produces marked reaction of the tissues. Edema is a sequel, while sloughs accrue and break off within a period of from three to ten days or more. Operations in the neighborhood of large vessels involve danger of serious secondary hemorrhage. Post-operative pain is usually not severe nor intractable. Healing occurs in three or four weeks, leaving scars which are usually soft and pliable. In operations involving the skin, there is often some tendency during healing toward keloid formation.

Electrodesiccation is a method of surgical diathermy which necessitates the use of a mono-terminal current of the Oudin or Tesla type, and a needle electrode. As has already been mentioned, desiccation is a dehydrating

process and is applicable to the treatment of superficial growths, such as warts, moles, keloids, papillomata, and the like.

The patient should be grounded by the use of a condenser couch or the holding of a metal cylinder, connected to the meter terminal. In this way an amperage reading is obtained and the hazard of shocking the patient is avoided. More frequently the protection by grounding may be omitted and the operation is successfully performed without a metered reading, which usually is very low and therefore of little value as a guide in monoterminal operations. Such has been the experience of Clark, Wyeth, Kobak, ourselves, and others. A foot switch is used to control the current. In operating, the needle electrode is inserted into the region to be treated and sufficient current allowed to pass to cause a blanching of the tissues. The needle is then withdrawn and another region treated. As in coagulation, the operation should extend into normal tissue, if possible. The penetrating effect of desiccation is more limited than that of coagulation. The post-operative course is very similar though less severe than that following electrocoagulation.

Fulguration is performed with mono- or bi-terminal currents, and a needle as the active electrode. This method is employed where charring or carbonization is desired. It is a valuable styptic in post-operative oozing or during operation for the control of hemorrhage.

The character of the spark is determined by bringing the needle electrode close to one of the metal connections of the diathermy machine. With the current turned on, a shower of sparks will jump between the electrode and the terminal of the machine. Following the sparking on the tissue treated, carbonization occurs which marks completion of the operation.

CHAPTER III

THE SINUSOIDAL CURRENT

The epochal labors of D'Arsonval in the early '80's, when repeating the work of Ward on alternating frequencies, led to the discovery not only of diathermy, but also of sinusoidalism. Credit for the development of the first sinusoidal type of current, and the encouragement of its application in therapy, therefore, belongs to D'Arsonval.

For therapeutic purposes the sinusoidal current is of distinct value wherever muscular contraction or intracellular massage is required. With the availability of the newer and perfected apparatus of low inductive currents, the contracting and decongestive action of the sine wave current has overshadowed the irritable faradic coil. Each, however, has a place of usefulness, so that the overlapping of these two modalties, therapeutically, is now a thing of the past. Laboratory and clinical experience has, furthermore, given us clear-cut pictures of the physiologic action and reaction of both types of induced current.

As a measure of testing early nerve degeneration, or as a diagnostic aid for the status of a nerve for its action of degeneration, the faradic current is of distinct value. Its therapeutic effect is vague, as it has proved of insignificant aid in the restoration of muscle tone as compared with the sinusoidal current.

We have already indicated that perfection of apparatus

has played an important rôle in again bringing into its own, physical agencies that were rapidly becoming discredited. Nowhere is this better exemplified than in sinusoidalism.

The capacity and mechanical construction of the early undulatory sinusoidal current apparatus were limited and crude compared with modern types of equipment. Moreover, the earlier machines, as designed by D'Arsonval, were constructed by Siemens on a variable resistance plan, with only two coils and brushes, against the modern ground free generator sets, with fixed or movable cams, multiple coils and brushes, which deliver higher frequency, greater voltage, smoother sensation and relatively low milliamperage.

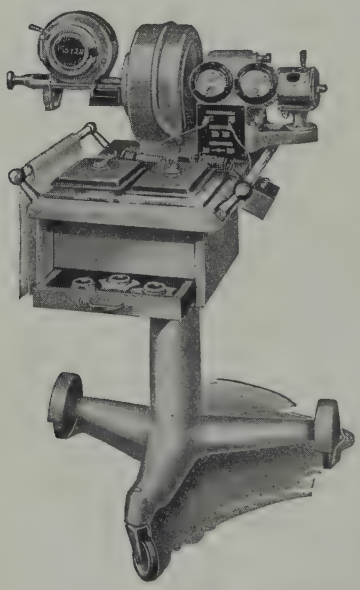


Fig. 20.—Morse Wave Generator.

A pioneer in physical therapy once graphically likened the older types of sinusoidal apparatus to the newer or generator types, by a comparison between a wheel revolving at a moderate rate of speed with the spokes plainly visible, and one revolving so rapidly that the spokes are not recognizable.

Since smoothness of sensation depends upon frequency of impulse, it can readily be understood that the modern instrument possesses greater superiority by virtue of the

larger number of coils and magnets. The Morse Wave Generator (Fig. 20), to cite an example, has twelve coils and twelve fixed and powerful opposing magnets with the armatures to further accentuate the principle, revolving at a high rate of speed. The more rapid the revolutions, the shorter the alternations of the current produced, the pleasanter the sensation, and the deeper the penetration. The revolution of the powerful magnets around the fixed coils, or *vice versa,* produces secondary inductions plus a cutting of the lines of electro-magnetic force (in the case of the Morse, to 12 times 12, *i.e.,* multiplying the number of coils by the number of magnets).

Fig. 20A.—The Fischer Universal Low Voltage Generator.

The sinusoidal current is of distinct advantage because it is practically painless when administered to a part, and because it is capable of exerting its effect without even slight electrolytic action. Its uniform, smooth, rhythmic, and wave-like action makes possible its application without ill effects even to such sensitive organs as the eyes. (Fig. 20A.)

Summarizing the facts which have thus far been stated, a sinusoidal current may be defined as an induction cur-

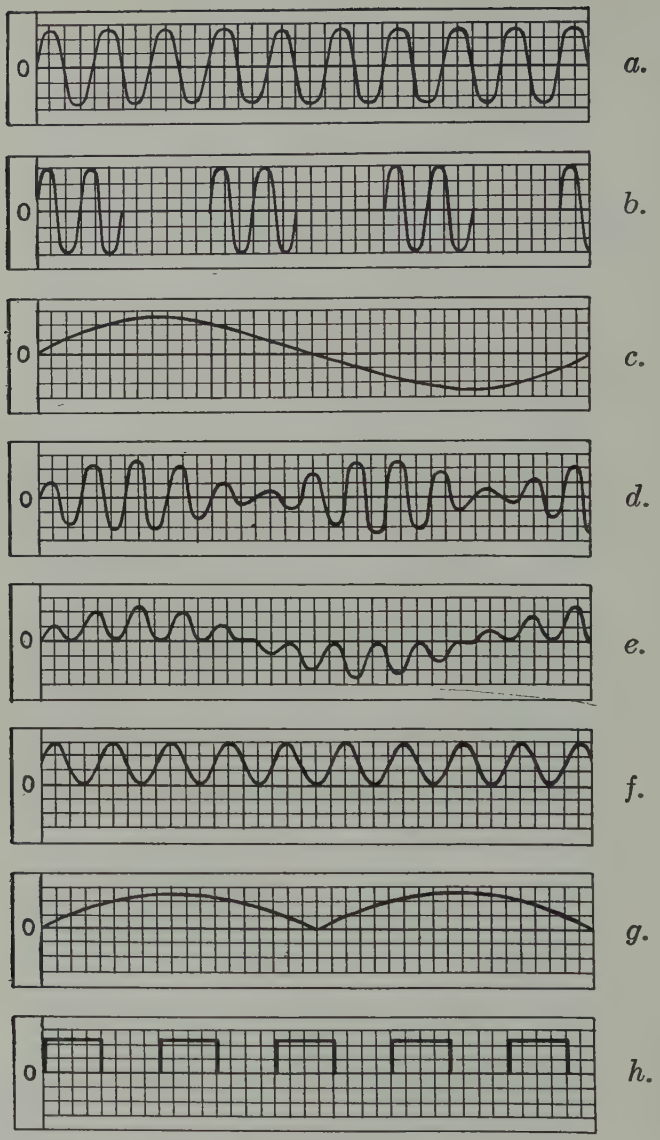


Fig. 21.—Graphic tracings of sinusoidal currents: *a*, Rapid sinusoidal; *b*, Interrupted sinusoidal; *c*, Slow sinusoidal; *d*, Surging sinusoidal; *e*, Superimposed wave; *f*, Combined galvanic and sinusoidal; *g*, Slow surging galvanic; *h*, Interrupted galvanic.

rent of low frequency, small volume, and short phasic duration, capable of producing muscular contractions which are uniform, rhythmic and painless. There are equal positive and negative phases, occurring slowly or rapidly, with moderate or intense effects, as desired, the two phases producing what is known as a sine or cycle. This is best illustrated graphically by tracing and starting the current from point zero, ascending to a peak, or maximum, in a perfectly regular curve, and in the same manner returning to zero; the tracing then descends into the opposite or negative phase of point zero in the same equal and regular manner, reaching its negative maximum phase and again returns to zero (Fig. 21).

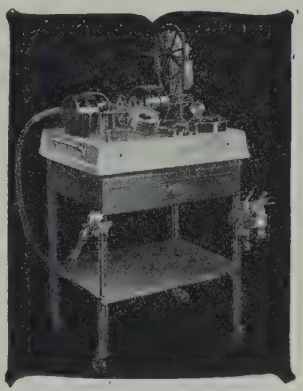


Fig. 22.—
Polysine Generator.

The current for the operation of a sinusoidal apparatus is obtained from the ordinary lighting circuit. An alternating current usually is more desirable, although most manufacturers construct two types of machines, one which operates on the alternating, and the other on the direct current. The Morse Wave Generator, the Fischer Universal Low Voltage Generator, the McIntosh Polysine and the Wantz Multiple Wave Generator are suitable for obtaining good sinusoidal currents. Each has some special features, but in the main, the clinical results obtained from any of them are quite satisfactory.

The Morse Wave Generator yields 4000 alternations or 8000 impulses a minute and applies this current in 20 or 24 waves a minute by means of suitable pad elec-

trodes which are thoroughly moistened before use. The McIntosh Polysine Generators (Fig. 22) are of two types, one for the alternating and one for the direct current. In this apparatus, the frequency of the waves and interruptions, as well as the strength of the current, may be regulated conveniently without stopping the treatment,

Fig. 23.—Wantz Multiple Wave Generator.

and both periodicity and voltage of currents are plainly indicated at all times. One may obtain a variety of effects from the Polysine, including the rapid, interrupted rapid, slow and surging sinusoidal; superimposed wave, combined galvanic and sinusoidal, and the galvanic both

in the usual and the interrupted form. The Wantz Multiple Wave Generator (Fig. 23) is capable of supplying the various types of sinusoidal currents, and may be energized by either the alternating or direct current because of the incorporation of a motor-generator set in every outfit. Dials regulate the polarity and the type of current desired; the voltage and milliamperage is gaged by visible meters for this purpose. In the Wappler apparatus, the 110 volt light current is reduced to a certain limit by a volt controller and rheotome, which are adjustable for each treatment. The maximum current limit may be set at any point, such as 20 or 25 milliamperes. The time consumed in a complete cycle is about five to six seconds. This apparatus is well adapted for the so-called slow sinusoidal current, although by certain adjustments, other wave currents may be secured. A motor-generator is necessary to convert the alternating to direct, and *vice versa,* if the machine is made for one line current only.

The positive and negative phases of the sinusoidal eliminate polarity effects by neutralization. The current is an unbroken one, and on account of its greater uniformity, a higher amperage than could possibly be borne by the faradic is tolerated. It is now believed that local metabolic effects are greater when positive and negative actions alternate and follow in quick succession.

The indications and contraindications for the administration of the sinusoidal current have not been definitely established, although all physiotherapists regard arteriosclerosis and a feeble heart as distinct contraindications to its use.

For general therapy the sinusoidal current may be applied through the moistened pad electrode or in an

electric bath. In eye, ear, nose and throat work, however, the electrodes are the same used for diathermy. When the bath method is employed, 30 or 40 milliamperes are generally sufficient. It has been estimated that twice as much current passes through the water as through the patient.

As much confusion frequently results from the terms *slow* and *rapid* sinusoidal, Sampson has called attention to the desirability of an author stating just which current he means. Sampson asserts that the terms "slow" and "fast" can be made to characterize the sine waves from a slow sinusoidal machine, and the term "rapid" be left for exclusive reference to the commercial alternating current where the waves change twenty-five, forty, sixty or one hundred and thirty-three times *per second* instead of a few times per minute as with the slow sinusoidal.

The application of electrodes is similar to that for galvanism. It is well to interpose between the skin and electrode a layer of moist chamois or felt. The electrodes must be in place before the current is turned on. Increase in intensity of the current must be gradual and always tolerable. Treatments should not be of long duration, and the current should be terminated as gradually as it is started.

The indications for the sinusoidal current in oto-rhino-laryngology and opthalmology are extremely limited. It may be used to advantage for muscle stimulation. By some it is thought to be of benefit in remote musculature of the special sensorium, such as the intrinsic muscles of the middle ear, or the external muscles of the eye. Some prefer the sinusoidal to positive or negative galvanism where the reparative action of the latter is

desired. Sinusoidal currents are contraindicated in acute and subacute inflammations.

We now possess many mechanical arrangements for interrupting the galvanic current, the chief purpose of which is to induce muscular contraction. Such a current is no doubt ideal for muscle testing, but has a limited use in therapy.

The wave galvanic current may be secured from any of the newer types of sinusoidal machines. Polarity effects are not altogether absent with this current, which has frequently been confused with the true sinusoidal. It has some application in our specialties, particularly where it is desired to administer prolonged treatments to muscles.

CHAPTER IV

RADIANT HEAT-LIGHT

Radiant heat-light is the energy transmitted by incandescent or luminous objects. For therapeutic purposes the tungsten or carbon filament lamp is most often used, and should be of high candle power. Luminous and incandescent objects radiate a variable amount of heat and light, depending upon the voltage and amperage in the circuit. This follows the law that amperage times voltage is equal to wattage.

$$A \times V = W$$

Usage as well as simplification of terms therefore demand that we think of high-powered radiant light lamps in terms of wattage instead of candle power. In this manner the physician can readily compute the intensity of the electric current across the circuit. For example given the two known factors of voltage and wattage we can compute the unknown factor—X (or amperage) by dividing the wattage by the voltage, thus:

$$\frac{W}{V} = X \text{ or amperes}$$

If W = 1500 and V = 110, the X (or amperage) would be $1500 \div 110 = 15.5$. Therefore, in this case the incandescence and intensity would amount to 15.5 amperes across the circuit.

The beneficial action of an incandescent lamp is not

entirely due to heat rays. A better understanding of the spectrum of incandescent lamps enables us to attribute their virtues not only to the heat (or infra-red) rays, but also to the light (or luminous) rays.

The wave length of light may be expressed in Angstrom units, an Angstrom unit (abbreviated A. u.) representing the wave length of soft X-rays, *i.e.*, one ten billionth of a metre.

The seven different colors of the spectrum which enter into the composition of white light are red, orange, yellow, green, blue, indigo and violet. These are the visible rays in contradistinction to numerous forms of invisible energy situated beyond either end of the spectrum. The invisible forms of light energy are the infra-red and ultra-violet rays.

The wave length of the visible spectrum (Fig. 24) commences at 7500 A. u. and extends to 3900 A. u.; from

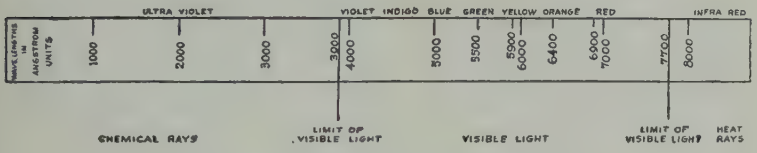


FIG. 24.—Diagram of the spectrum.

the beginning of the red to the end of the violet. From this wave length to 1850 A. u. extends the ultraviolet spectrum (therapeutic limit). Schumann and Lyman have extended the ultraviolet spectrum up to 600 A. u. and Millikan to 360 A. u. Beyond this is the unexplored region. In comparison with the Angstrom unit based on soft X-rays, the very penetrating gamma rays from radium have a wave length of about 0.07 A. u.

Some writers prefer to divide the spectrum somewhat

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differently, using, instead of Angstrom unit, the millimicron—one billionth of a meter. They divide the spectrum into three parts; an invisible portion beyond the red, with wave lengths increasing from 700 u. u. to those of vast proportions, known as the infra-red region; a visible portion called light, which has varying wave lengths from 700 to 390 u. u.; and an invisible portion, the non-luminous spectrum, with a decreasing wave length from 390 u. u. to zero, which is called the unexplored region of Millikan the X-ray field and the field of radium frequencies.

The invisible infra-red rays have great penetrating power, but are demonstrable only as heat. The powers of penetration of the luminous rays gradually recede in direct proportion as one nears the ultraviolet region, while the absorptive properties increase as one approaches the shorter wave length in the ultraviolet field. Thence occurs an apparently unexplained paradox of dynamics, whereby, as we approach the X-ray region and that of the gamma rays, instead of a corresponding increase of absorption, we again note increased penetrating properties of these energies.

In dealing with radiant energy, one must differentiate properties of penetration from properties of absorption. As has been indicated, the longer wave lengths, such as are given off by the deep therapy lamps, carry mainly qualities of penetration, and these have a profound electrochemical effect upon nuclear chromatic and cellular vitality. Absorption of radiant energy follows penetration when dealing with the longer wave lengths. When this energy is absorbed into living tissue, it is converted into heat or calories, and this brings about an activation of cellular metabolism, not only of the irradiated part,

but also distally, through the vasomotor changes that always follow hyperemia.

Turrell believes that there does not appear any reason or physical grounds for expecting any marked difference in action between the radiant energy derived from the rays of the sun and the radiant energy obtained from the incandescent filaments of electric lamps. With this contention we do not take issue. We do, however, differ with Turrell in his view that the color of the incandescent lamps in no way influences the effectiveness of the treatment.

Heat by penetration is quite different from heat by convection. Radiant energy is best transmitted through glass that is clearly transparent. Ordinarily glass will transmit only the luminous rays of the spectrum, leaving out the invisible rays of the infra-red and ultraviolet regions. This, of course, is most desirable in some conditions where the maximum effect of deep therapy light is wanted. However, in the application of ultraviolet light, uncolored glass is an undesirable medium, because it is highly opaque to the rays of short wave lengths, especially the actinic rays.

Colored glass is inefficient for radiant heat lamps because its use is not in accord with the principles involved in the physics of optics. Colored, screened glass transmits wave lengths of its color only, the remainder of the energy is absorbed, heating the glass itself and giving off convective heat. On the other hand, transparent glass transmits all the rays of the luminous spectrum upon the irradiated part, permitting penetration, absorption and electrochemical changes.

All the benefits of an active hyperemia, such as vigorous drainage of the affected part, relief of stasis, which

is the cause of cellular death, and the disposal of morbid waste products, *e.g.*, toxins and endotoxins, follow radiant energy. Thus, local heat from radiant light is decongestive locally, or generally, because it overcomes stasis. Thermo-penetration has a bactericidal effect because certain bacteria cannot live in all temperatures. Increased oxidation always follows increased metabolism. Hyperemia of the skin, with a concomitant depletion of the internal organs, produces a lowering of the blood pressure, while the respiration rate is diminished and the respiratory exchange is increased, favoring the removal of volatile waste products and carbon dioxide.

It is quite obvious that to some extent, at least, the action of light-heat rays depends upon the method of application and the parts irradiated. In otitis media, for example, it is not necessary to focus or concentrate the rays, yet it is essential to include a larger area than is involved pathologically. The lamp should be so directed that the rays are as vertical as possible in relation to the area to be treated.

The point of greatest heat from the application of radiant light and heat is the proximal surface. The facility with which the application is made, by means of a properly constructed incandescent lamp, makes the method a very desirable one. It combines convective and conversive heat, and there is positive proof that the rays penetrate some distance, producing an effect which must be attributed, not only to the heat, but also to the therapeutic properties which these luminous rays possess. Strebel long ago demonstrated that the effects produced are due to the light rays, the associated heat rays, or to both.

There is a variety of radiant heat lamps on the market.

The candle power or wattage of the bulb, and the size, shape and construction of the reflectors differ materially. We prefer a lamp with a 1000 to 1500 watt bulb of uncolored glass, so arranged within a suitable reflector as to transmit the rays vertically upon the object at any desired distance. The shape and size of the reflector affect the therapeutic value of the rays. These points

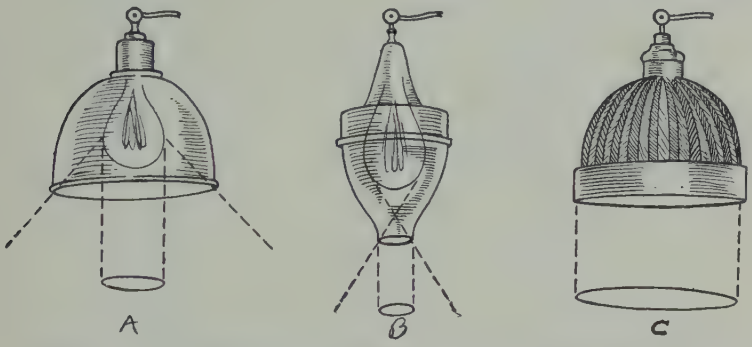


FIG. 25.—*A*, Great dispersion of light rays, area of vertical rays greater than in lamp with base opening of small diameter; *B*, Showing hot spot and dispersion of rays, also minimum amount of verticle rays emitted through base opening of small diameter; *C*, Maximum amount of verticle rays with minimum dispersion due to fluted bowl and skirt and absence of diaphragm.

of lamp construction are shown in Fig. 25. The reflecting surface is best made of white porcelain, parabolic in shape. Such a reflector allows no undue absorption of heat and insures proper reflection of the light rays.

Much absorption of heat takes place if the reflector is small and closed off at the bottom in a way to interfere with proper ventilation and cooling of the lamp. The most desirable reflector (Fig. 26) for the purpose of irradiating an ear is one which is large enough to house a high wattage bulb, and of a shape to reflect, as verti-

cally as possible, the light rays on the part to be irradiated. It is preferable to expose a larger area of the body than is affected and this is best accomplished by a reflector with a wide base.

The use of radiant heat about the head is relatively simple. Several points should be emphasized, particularly with reference to frequency and duration of treatments. Radiant heat-light should be administered frequently, never less than once and, if possible, several times daily, depending on the symptoms and the relief obtained by the radiations. Twenty minutes is the average duration for a single treatment. If the patient is confined to bed, this time may be extended indefinitely. Many patients are so gratified with the relief of pain which radiant heat-light affords in some affections, that they insist upon almost constant exposure. There are few, if any, contraindications to this therapy and none to long durations of the exposures.

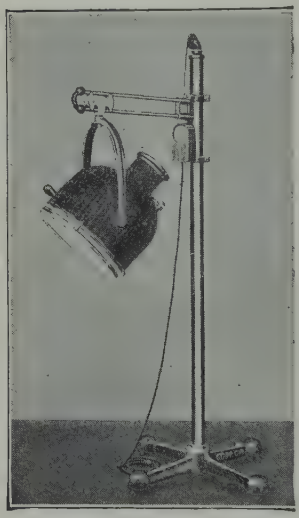


Fig. 26.—A flexible type of radiant heat lamp.

Care must be taken that the lamp is not too close to the body. Lamps without adequate cooling arrangements get quite hot, and burns may occur from contact with the reflector. The lamp should be suspended from a wall bracket or an adjustable floor stand in a manner to insure easy shifting.

The comfort of the patient while taking the treatment

is an important factor. Patients who come to the office should be placed on a low couch or on a reclining chair. It is poor practice to use the sitting position. Protection of the eyes by colored glasses is a precaution which is not to be slighted.

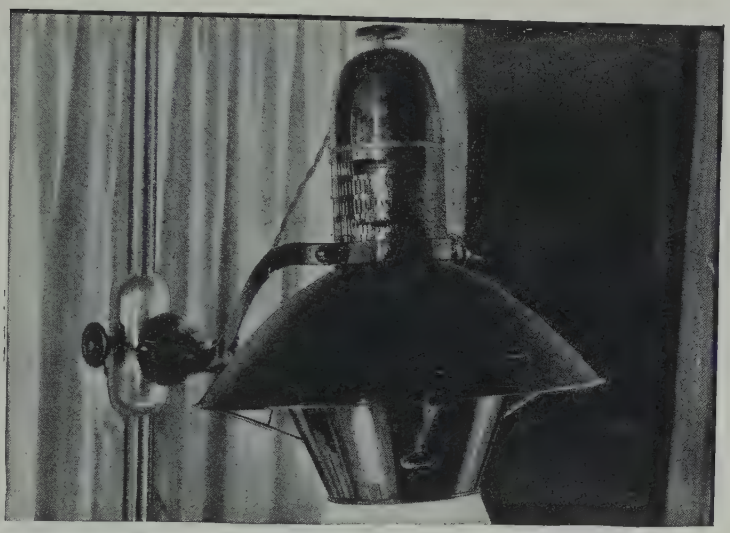
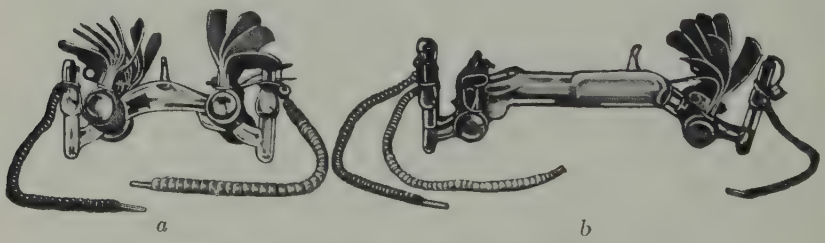


Fig. 26A.—Large "Sollux" lamp for radiant heat therapy.

CHAPTER V

ULTRAVIOLET LIGHT

Study of spectra has demonstrated that there exist radiations beyond the violet end of the visible spectrum, having wave lengths varying from 3900 to 1850 Angstrom units. These rays are of therapeutic value and are referred to as *ultraviolet light.* Rays of shorter wave length have been recorded successfully by Schumann, Lyman, Richardson and Bazzoni down to about 400 Angstrom units, following which is the so-called unexplored region of Millikan. These rays, however, are absorbed by the atmosphere and so have no import at this point.



a *b*

FIG. 27.—"Alpine Sun" burners for *a*, direct current and *b*, for alternating current.

Ultraviolet light is sometimes called the *actinic* or *chemical ray* because of its ability to excite chemical action and because its effect upon photographic paper is greater than the effect produced by other parts of the

spectrum. It is incorrect to use the term "sunlight therapy" as a synonym for ultraviolet therapy, as the former consists of three divisions: 1.—heat, 2.—visible light, and 3.—a variable quantity of ultraviolet radiations depending upon seasonal and atmospheric factors. Since the foregoing factors are not constant, the sun frequently

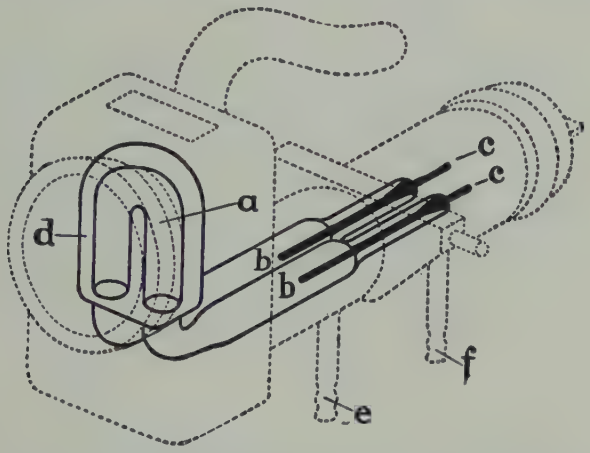


Fig. 28.—Direct current water-cooled Kromayer burner. *a*, arc tube; *bb*, mercury container; *cc*, ground-in, mercury-sealed rods; *d*, evacuated quartz jacket; *e*, inlet of water; *f*, outlet. The alternating current burner is similar to that used for direct current excepting that the arc tube is W-shaped and is supplied with three of the electrode vessels (*bb*) and three current terminals.

cannot be employed and other sources of ultraviolet light must be used therapeutically. Mercury vapor quartz or open arc lamps serve this purpose. (Figs. 27 and 28.) In the former an electrical current is made to pass through a quartz tube in a medium of mercury vapor (Figs. 29 and 30), while in the latter the current is made to pass between two electrodes which are either of

carbon, copper, tungsten, aluminum, or other metals or combinations of them. (Fig. 31.) The spectroscopic analysis of all light, so produced, shows a wealth of ultraviolet rays, but the abundance of rays of definite wave length is dependent upon the source of light.

As can be seen, the spectra show few bands beyond the region of 2000 Angstrom units. To obtain a greater

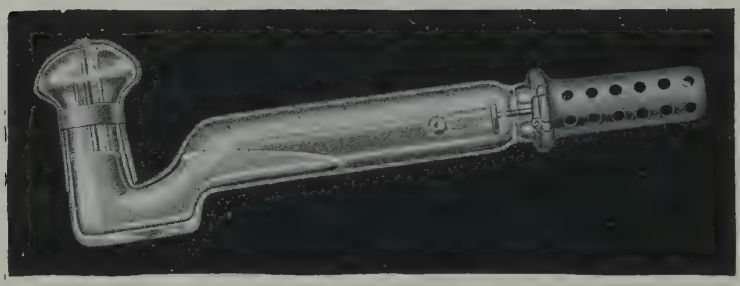


Fig. 29.—Air-cooled "Uviarc burner.

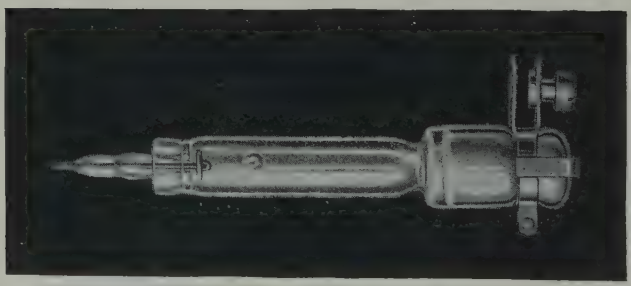


Fig. 30.—Water-cooled "Uviarc" burner.

quantity of radiations the water-cooled ultraviolet lamp is employed. The shorter rays are very intense and produce reactions in much shorter time than the longer ones.

All ultraviolet rays have limited penetrating properties. They are very easily absorbed by the tissues and to varying degrees by the media of the eye. The cornea absorbs all rays shorter than 2950 A. u., while the lens is capable of absorbing those of 3000-4000 A. u.

To obtain deepest penetration, suitable quartz applicators are attached to the lamps. The tissue to be treated is compressed by the applicators. This is done to make the tissue as thin as possible and to force out the blood. Blood absorbs ultraviolet rays very easily and its presence therefore hinders their passage. It has been shown by Harris, and A. F. Hess that the simultaneous action of ultraviolet rays and visible light resulted in nearly a complete annulment of all activity. This suggests the antagonistic effects of long and short light rays. The chromatin substance of nuclei is very opaque to ultraviolet light, or, in other words, it absorbs ultraviolet light very readily. The result of this absorption persists for four or five days and produces many biochemical products, the exact nature and action of which are still under investigation.

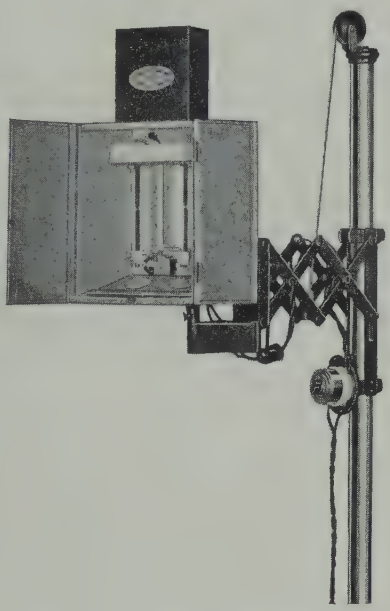


Fig. 31.—Arc lamp (Johnson type).

The effects of the sun's rays in nutritional diseases,

such as anemia and rickets, was spoken of by Perreira as early as 1848. Finsen demonstrated some time later that artificial light had curative properties, but that this action depended upon the blue and violet rays. Finsen also demonstrated that a concentrated focused light, transmitting as many blue, violet and ultraviolet rays as possible (comparable to the concentrated electric light of Finsen) is necessary. This light kills bacteria in a few seconds when spread on a thin film of agar.

Rays from regions of different wave lengths are capable of exerting different effects on living beings. Ellis and Wells describe two actions, viz., *stimulative,* since stimulation of biologic processes is their commonest expression, and *lethal,* since it is characterized by the death of the cells on which they are exerted. The stimulative action, as given by these authors, is exerted by the ultraviolet rays from the limit of the visible spectrum to about 2900 A. u.; the lethal effect by the rays of wave lengths shorter than 2900 A. u.

The lethal effect is familiar to most of us as the germicidal action of the utraviolet rays. Finsen early recognized this and applied these rays, by means of a special apparatus of his own construction, to skin infections, such as lupus.

Kattenbracker's experiments with reference to the action of light on bacteria were conducted with the light from a lamp, which was a modification of Finsen's, at a distance of 10 centimeters. He used 15 per cent nutritive gelatine as a culture medium for gonococci and tubercle bacilli; 2 per cent glycerine agar, covered with sterilized blood serum, for typhoid and other germs. The germs were grown in surface cultures on plates at a temperature of 22 degrees C. The control cultures

were kept at 35 degrees C. to allow for the slight rise in the temperature of the light from the lamp. Inoculation from the rayed cultures on glycerine agar was made after forty-eight hours, and the new culture kept at a temperature of 35 degrees C. for forty-eight hours. The relative viability of the new cultures was taken as a criterion for the relative germicidal power of the light.

Typhoid Bacillus.—After an exposure to Kjeldsen's light, lasting one second, there was no effect. After three seconds, growth was markedly impaired. After thirty seconds, vitality was virtually suspended. After sixty seconds, the culture was dead.

Tubercle Bacillus.—Slight impairment after five seconds. Marked impairment after thirty seconds. Death after two minutes.

Micrococcus Gonorrhea.—Slight impairment after five seconds. Marked impairment after thirty seconds. Death after two minutes.

Streptococcus Pyogenes.—Impairment after thirty seconds. Death after three minutes.

It is quite evident from these experiments, and from others conducted since, that all types of bacteria are not affected alike. Undoubtedly the resistant power of certain organisms plays a rôle, as does the accessibility of infected areas, the underlying pathologic condition, the state of body metabolism and many other factors.

Turrell's explanation is based on the work of Hertel, who investigated the lethal action of ultraviolet radiation on bacteria. Both accept that the action is due to reduction, because they found that green hydrae were less affected by ultraviolet light than the colorless ones, probably owing to the protection obtained from the oxygen supplied by the chlorophyl.

Certain effects of ultraviolet radiation on the chemistry

and histology of the blood have also been determined. Koopman reported that the concentration of erythrocytes is not changed. The leucocyte count increases the first hour, then decreases and remains low six hours after irradiation. The neutrophile count is usually increased during the first few hours, while the lymphocytes are increased. More notable are the facts that Koopman found no changes in hemoglobin, viscosity and coagulation points.

Other investigators call attention to the increase of alkalinity of the blood due to body irradiations; also to the fact that light, as evidenced by continuous bright sunlight, increased temperature, lessened humidity, materially influenced the effect of light upon the reaction of the blood.

The experience with ultraviolet light in rickets, tetany and spasmophila, on a blood calcium deficiency basis, has definitely established that the quartz rays will not only raise the calcium content of the blood, but will also "fix" it. Quartz light will thus maintain animals free from rickets, even though fed on a diet known to produce this disease. Hess and Unger reported on the use of the carbon arc light in the prevention of rickets and noted an accompanying constant increase in the inorganic phosphates of the blood. Interesting also is the work of Hoag, who treated infantile tetany with ultraviolet light and found that the serum calcium returned to normal limits.

Hart, Steenbock and Elvehjem investigated the effect of light upon phosphorus and calcium equilibrium in lactating animals and obtained results which showed that ultraviolet rays favorably influence the storage of calcium and phosphorous.

Novak and Hollender some time ago reported their observations that the calcium content is invariably low in hyperesthetic rhinitis, and sometimes also in seasonal hay fever and asthma. They established the fact that these affections are not influenced by calcium alone, that calcium lactate combined with thyroid extract affords temporary relief in all cases of hyperesthetic rhinitis and in some cases of hay fever and bronchial asthma; and that exposure to the mercury vapor quartz lamp, together with the combined calcium thyroid therapy, appears to fix permanently the calcium content of the blood serum.

The influence of so-called sensitizing substances injected into animals who are later exposed to ultraviolet rays has been studied. Quinine, resorcin and aniline dyes have been employed at various times. It is justifiable to conclude from the observations made that these drugs may produce an increased sensitivity to ultraviolet light.

Robertson believes that plant anemia and human anemia are both curable by sunlight. In the case of the plant, the anemia is due to reduced chlorophyl, and exposure to sunlight develops the chemical. In the dark the chlorophyl pigments, carotin and xanthophyl, tend to disappear. Sudden exposure to light will kill such plants, as the ultraviolet rays are badly borne by plant life, and the absence of pigments prevents protective absorption.

Plants grown in the dark starve. This fact is analogous in animals in which the metabolism of carbon compounds is likewise lessened in the dark. "In the absence of normal metabolic change, the reserve nutrient supply is not consumed as rapidly as in light." (Robertson.)

Ultraviolet light will irritate normal skin and produce surface skin changes. The effect first to follow radiation

is an erythema, and later considerable local irritation. The erythema produced by ultraviolet light is similar to *sunburn* (erythema solare). This is not an effect of heat, but probably the result of some photochemical reaction, acting on the arterioles, and experience has taught that it is most likely to occur in cold surroundings.

Hill and Eidenow and others have shown that erythema with subsequent desquamation and pigmentation occurs after the human skin has been irradiated with ultraviolet rays shorter than about 3200 A. u. Longer wave lengths (3300 to 3900 A. u.) do not produce erythema and appear to resemble luminous rays in many of their biological actions. Rays with a wave length of 2970 A. u. give a maximal effect.

Finsen has demonstrated that normal blood absorbs light rays in large amounts, and it is quite possible that changes in the chemistry of the blood results therefrom. Exposure to the sun will produce a general leucocytosis with relative lymphocytosis, effects which result also from exposure to the rays of the mercury vapor quartz or open arc lamps.

That ultraviolet rays possess penetrating qualities has been known for many years from the experiments of Finsen, Jansen and Gebhardt. Finsen's original method was to concentrate actinic light through rock crystal lenses. The light could be focussed on any body area which had been first rendered as bloodless as possible, for Finsen believed that the presence of blood in a part rendered that part impenetrable to the chemical rays and therefore prevented results as far as any effect on the tissues is concerned.

It is thought that the ultraviolet rays from the mercury-quartz lamp have a superficial effect, the depth of

penetration depending on the type of tissue and the freedom from foreign deposit. Contact applications with the water-cooled apparatus are not now employed except in glandular affections, where deep penetration and marked reaction are sought.

The effects of the actinic rays are due to either local or general radiation. The local action is regarded as stimulating or destructive; the general, as biologic or metabolic. The latter action has a decided influence on body metabolism and on some of the chemical constituents of the blood. These contentions are based on experimental work with the mercury-quartz lamp, and similar effects have been obtained with the carbon arc light as well.

Carbon arc light contains all the rays of the spectrum, while mercury light mainly contains ultraviolet and particularly short-wave rays, with but slight powers of penetration. It is thought by Reyn that the effect of light in the deeper tissues is best obtained from a carbon arc lamp.

That the shorter rays from the mercury vapor quartz lamp exert a stimulating effect has already been noted. Some prefer to classify this action somewhat differently, including under the one head, both stimulating and irritating effects. The longer rays exert a "tonic" influence, better understood to mean a regenerative reaction.

The technic has not been universally standardized, but on the basis of the above classification of the rays, the following methods have proven successful. For the usual systemic "tonic" treatment given alone or supplementary to local treatment, the individual lies on a couch, bared to the waist. The body is thoroughly dried with a towel, dark colored glasses are placed over the eyes, and

the lamp is set twenty-five to thirty inches from the part to be irradiated. This distance is maintained at all subsequent treatments. If the intensity is to be increased, the duration of the exposure is made longer. The chest, back and both sides are in turn brought directly under the lamp. The arms should be held over the head. Just as frequently the lower half of the body may be similarly exposed. The initial radiations should be given very cautiously, and an estimation made of the reactivity and receptivity of the skin. Subsequent radiations are gradually lengthened, until the time of an exposure reaches twenty minutes. It is improper to exceed this limit. Exposures should be given three times weekly.

If after the first or second treatment, untoward symptoms appear, such as malaise, headaches, cough or rhinitis, the irradiations should be discontinued. General ultraviolet exposures should not be administered during the menstrual period because of the increased tendency towards hemorrhage at that time.

To secure so-called alterative or stimulating effects, the distance between lamp and patient should be shortened. The intensity of the treatment is increased by lowering the lamp, the time element remaining unchanged.

The technic with the carbon and tungsten arc lamps is similar to that with the mercury vapor quartz appliances, save that the time element is markedly increased due to the fact that the heat of the lamp makes its use impossible at short range.

It is important to know that the skin and body may develop a relative immunity to ultraviolet radiations from a single source, and fail to respond to treatment. Substitution of another type of lamp most frequently

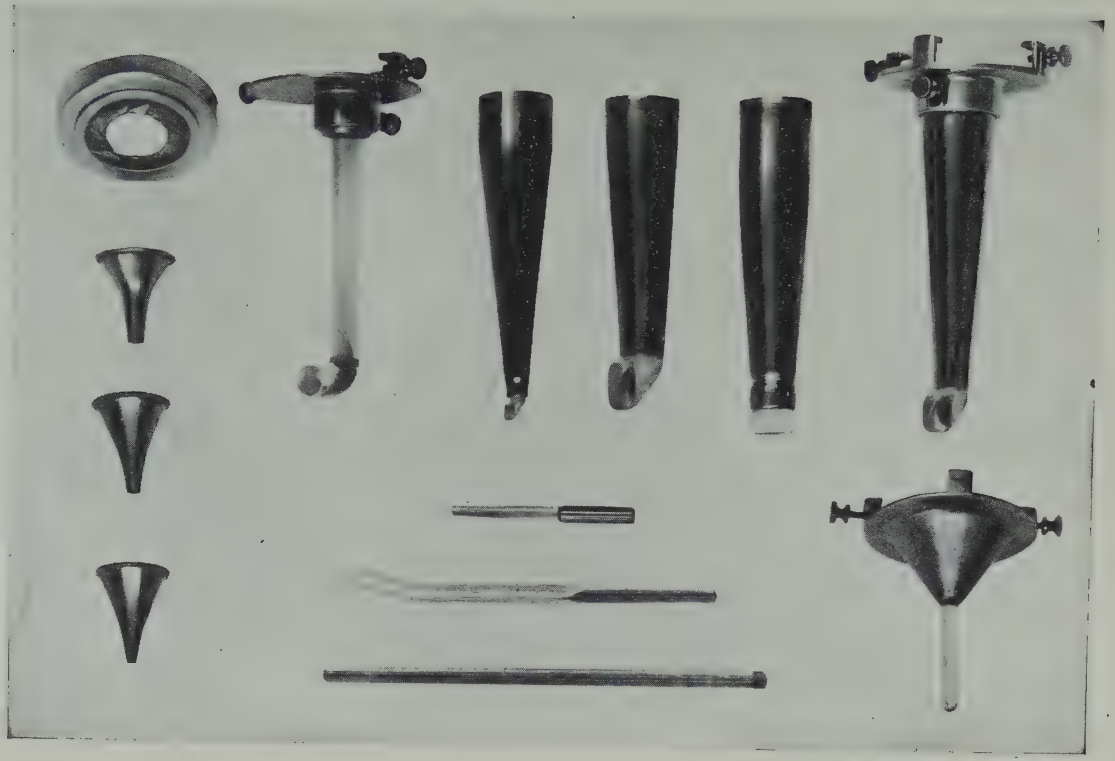


FIG. 32.—Quartz applicators.

stimulates once more the tissues irradiated, and at some subsequent time another change or a return to the original lamp may be necessary to maintain the desired reactions.[1]

In preparing the water-cooled quartz unit for use, the water must first be turned on and set circulating about the burner. The rate of flow must be moderate and steady. The rheostat is set for "low," the current is turned on, and the lamp tilted and straightened to complete the arc. The applicators may now be attached and the rheostat gradually turned to "high." In the newest model water-cooled quartz units the maximum voltage may be attained in two to three minutes. The lamp should remain in a horizontal position for all radiations. Solid quartz applicators are preferred to hollow metal cylinders with only quartz condensers at the ends (Fig. 32). Quartz reflectors in the form of prisms are very valuable in approaching the larynx and the nasopharynx.

Skin surfaces may be treated with the lamp at distances varying from one-half to six inches, or at contact, by using a large quartz compressor. The time of exposure varies inversely to the square of the distance.

According to Hill and Eidinow, the ultraviolet intensity of a lamp and the dose of light employed may be expressed in terms of infusoria-killing units, each I. K. unit being equivalent to the time required to destroy infusoria placed in a water-cooled quartz cell of standard width at 20 degrees C. The minimal erythema dose in a normal white skin usually corresponds to 2 I. K. units, and varies according to the individual sensitiveness of the skin. Methods for determining the sensitiveness of

[1] These facts are confirmed by the recent experimental work of Hill and Eidinow.

the skin and for estimating the bactericidal power of the blood before and after irradiation have recently been described.

Pharyngeal and laryngeal applications must be made cautiously as the mucous membranes of the pharynx and larynx will not tolerate intense ultraviolet light as compared with the membranes of the nose. The treatment of the nose with quartz rays has long been unsatisfactory. This may be attributed to the failure of penetration of the thick mucus covering the nasal membranes. The nose should be properly prepared if the rays are to be therapeutically effective. Several preliminary measures serve the purpose; namely, (1) intranasal diathermy, (2) argyrol tamponage, (3) tamponage with a weak solution of magnesium sulphate.

The nasal applicator is introduced into the nose, after being inserted in its place on the lamp. The lamp should not be held by the attendant, but should be fixed on the bracket or portable stand in such a way that it can be brought up to the patient who sits in a chair next to it. The patient should relax and be made thoroughly comfortable during the entire procedure. When nasal applicators are employed, the patient should withdraw from the lamp at short intervals. The reasons are obvious. The intensity of the rays is at the tip of the applicator, and by frequent withdrawals during a treatment all surfaces of the nasal membrane are irradiated.

For some nasal affections, direct raying of the mucosa, without quartz applicators, is desirable. The preliminary measures of preparation are carried out; then a bilateral funnel-shaped speculum (Fig. 33) with fair-sized openings is attached to the lamp. The patient adjusts himself in such a way that the rays are directed into the

nasal chambers. The time duration of such a treatment is gaged by the factors already mentioned. On the average, three to five minutes will suffice, providing tolerance has been built up by previous radiations.

Quartz rods are employed for either external or middle ear affections. Short exposures are usually advocated,

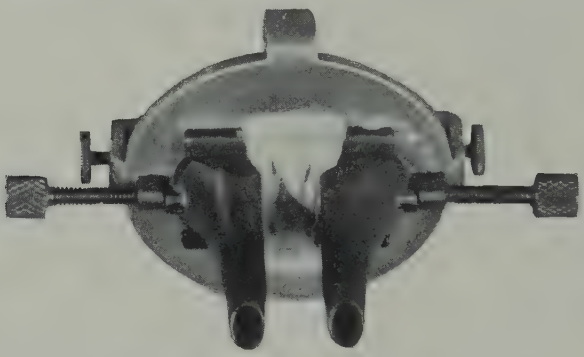


Fig. 33.—Bilateral nasal speculum for direct irradiation.

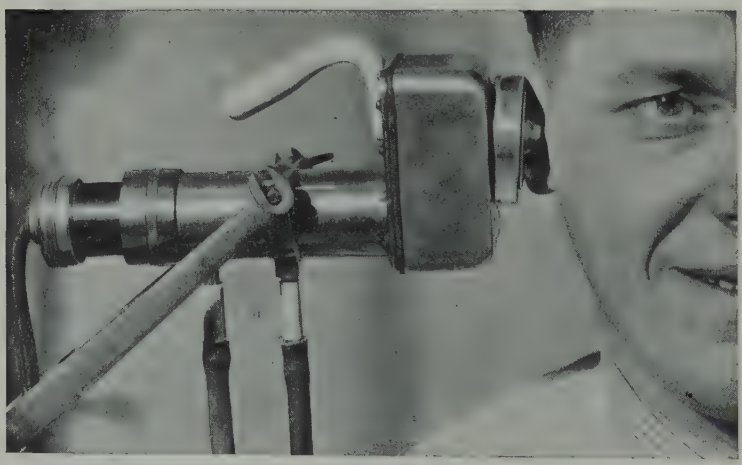


Fig. 34.—Direct raying of ear canal (note that no quartz rod is used).

but here again no definite rules can be laid down. Direct raying of the ear canals is valuable in some cases. (Fig. 34.) The use of sensitizing substances in the nose and in the ear are discussed under the treatment of nasal and ear diseases.

The cornea and conjunctiva may be treated with small quartz or prismatic applicators at short distances. The local reaction and bactericidal effects are greatest at close range and diminish with the intervening distance between the lamp and the part irradiated.

CHAPTER VI

X-RAYS

Professor Roentgen, while experimenting with vacuum tubes known as Geissler and Crooks tubes, discovered that when a tube of partial vacuum was charged with a high-tension electric current, certain rays were generated, which, though not visible, had the power of fogging photographic plates. He found also that he was able to illuminate a fluorescent screen at a considerable distance away from the tube. Owing to the unknown character of these peculiar rays, he named them X-rays.

The rays so generated were later found to be capable of penetrating many elements otherwise opaque to ordinary light. The different elements in the human body seemed to offer varied resistances to the rays, the more dense tissue permitting less of the rays to reach a photographic plate. The result naturally was the recording of a lighter image, perfect outlines of the bones and other internal organs being clearly defined.

Experimentation gradually led to the recognition that the X-rays had a decided effect on animal tissue, an effect which differs according to the apparatus employed and the dosage of the rays. Other factors, too, play their part, so that the use of X-rays for therapeutic purposes requires at least an elementary knowledge of the principles involved.

Inasmuch as development of the high-tension current was a comparatively simple matter, it was soon recog-

nized that the really essential portion of the appliance is the tube which produces the X-rays, because the best apparatus for the production of high-tension currents will prove valueless if an improperly designed or poorly constructed tube is used.

X-ray tubes consist of thin-walled glass bulbs, into which project two hermetically sealed terminals through which the high-tension currents pass. The negative terminal, which is termed the cathode, terminates in a concave surface with radii focusing on the surface of the positive terminal, known as the anode or target.

When the negative side of the high-tension current is connected to this cathode, minute electric particles, or cathode rays, fly off at right angles to its surface, and owing to the shape of the cathode these particles focus on the target from which X-rays are radiated in all directions. When this high-tension current is of sufficient power, these little particles continue to strike the target and a continuous beam of X-rays is emitted. The target surface sets at an angle of 45° so that the X-rays can be projected outside of the tube where they can be used. The greater number of them, therefore, is radiated at the angle of reflection, considering the angle of approach of the cathode the angle of incidence.

The cathode rays coming in rapid succession and impinging upon the target is very similar to the continuous striking of a hammer, with a consequent transformation of energy—heat. Heat is radiated at the point of the impingement on the target, depending upon the number of cathode rays and the speed at which they travel. This heat which can easily reach a melting point, regardless of the material used in the target, will destroy the target and change the quality of the rays produced.

The penetrating power of these rays varies with the voltage across the terminals.

Two types of tubes are used. The older one of the two, known as the gas tube, is not exhausted to a perfect vacuum. A small amount of air is permitted to remain as conductor for the cathode rays. The amount of gas left within the tube controls the amount of current that will pass through the tube for a given voltage across its terminals. In prolonged usage, some of the gas will be absorbed by the metal parts and some will be deposited on the glass wall of the tube. A so-called regenerating device which became a necessary part of every gas tube is nothing more than a chemical to release small amounts of gas into the tube when an electric current is passed through it. The device usually consists of a smaller tube with an additional terminal to which one terminal of the high-tension current can be connected, and through which currents of short duration can act on the chemical releasing the gas as desired.

A distinct disadvantage of the gas tube is the fact that heating of the anode during heavy or prolonged exposures releases gas from the metal parts of the tube. This lowers the vacuum, which in turn increases both the amount of current through the tube, and the heat of the anode. The process makes this form of tube difficult to operate and calls for continued watchfulness on the part of the operator. If due care is taken, the small amount of gas liberated by the anode in such instances will be reabsorbed after the tube cools off. There are times, however, when the amount of gas liberated is of such proportions that the amount reabsorbed is insufficient and the tube then becomes useless unless it is re-exhausted.

The other type of tube known as the Coolidge tube has rapidly replaced the old gas tube and is now used almost exclusively. The basis of its operation is a method which involves a hot cathode from which electrons are emitted to act as a medium for carrying the current through the tube. The amount of high-tension current that will pass through the tube depends upon the temperature of the filament in the cathode, this filament being heated electrically from an independent outside source of low voltage.

The Coolidge cathode and filament combined are located as in the gas tube and the emanations focus similarly. However, the current desired is not controlled by the amount of gas within the tube as the tube is pumped nearly to an absolute vacuum and the amount of current passing is in proportion only to the heating of the cathode element. With suitable arrangements for control of this heat the operator has, at all times, perfect control of the current through this form of tube.

The high-tension current necessary for exciting different types of tubes is generally produced by a step-up transformer which is far superior to the old inefficient tesla and induction coils, as well as the old static machines.

Static machines furnish an extremely high voltage direct current for X-ray work, but owing to the fact that the machine has to be built very large, and of very many pairs of plates to produce the amperage in sufficient quantity, it is replaced by the induction coil, very similar in construction to the present-day transformer, but without a closed iron core. The magnetic flux travels through the air which offers a very high resistance, a

fact which reduces efficiency. The induction coil operates on a direct current. A magnetic vibratory interrupter is used on the small type of induction coil, and electrolytic or mercury interrupters on the larger sizes.

The interrupted current was passed through a series of turns of heavy copper wire, inducing a current in the secondary circuit, somewhat similar to the winding on the modern alternating current transformer. On the modern transformer a true sine wave is produced, whereas in the induction coil the current produced was almost of a true direct current nature.

The modern high-tension transformer operates on alternating current and furnishes such a current of high voltage. The transformer consists of a laminated, soft iron core on which insulated, heavy primary wire is wound for the primary circuit, and, as in the case of the induction coil, the secondary consists of many hundreds of turns of finer, insulated wire. This wire is wound on spools and the spools connected in series. The ratio of the turns of the primary as compared with the turns of the secondary govern the voltage produced.

As has been mentioned, the current is of high voltage and the voltage of one complete cycle is just as great above the line as below, necessitating the use of some rectifying device. One commonly used is shaped like a rotating disc connected to a synchronous motor. Such a rectifier is very efficient. Another is the modern self-rectifying Coolidge tube, which takes the alternating current from the transformer and permits but one side of the wave to pass. It is said that such a tube will stand 100 m. a. at a 85,000 peak voltage for 10 seconds. There are other self-rectifying devices on the market at the present time, such as the Army tube which rectifies cur-

rent up to 5″ back ups, or about 85,000 peak volts, carrying this current for periods of 15 to 20 seconds.

For our purposes, that is to say, for the treatment of the conditions usually encountered in oto-laryngologic practice, tubes with lesser penetrating power are required. The only exceptions are primary or metastatic malignancies. As a general proposition, we need for our work a small X-ray apparatus giving us as little as a 5″ back up spark gap. A Coolidge tube with a radiator arrangement (Fig. 35) is to be preferred because it exceeds in

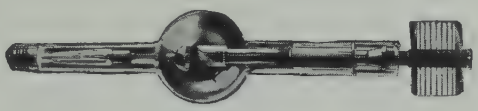


Fig. 35.—Coolidge tube with radiator arrangement.

therapeutic efficiency any other tube manufactured at the present time.

There are various makes of X-ray machines which are well adapted for "small dosage" work. Attention is directed to the great care which must be exercised in the hook up, and in the protection or insulation of exposed parts of the machine and the wiring. It is not infrequent that these latter precautions are disregarded, resulting in injury to the operator.

It is well established that dosage of X-rays is of therapeutic importance. Stimulation, inhibition or destruction may be produced, depending on the dosage used. The X-rays also have a selective action on new or embryonic cells. An "ionizing" dose is very small, less than a "stimulating" dose. For instance, an "ionizing" dose may be given with a 5″ back-up spark gap, 12″ anode skin distance, three millimeters aluminum filter

and a five milliampere-minute dose. The skin distance and filter, or any of the other factors, may be modified to suit the individual case. Often a 7″ or a 9″ spark gap is necessary. Stokes advocates a so-called "diminutive" dose of X-ray for the treatment of partial deafness. This work is described in greater detail in a later chapter.

Small X-ray dosage is said to be more efficient when used in conjunction with other physical agents, viz., ultraviolet rays, conversive heat, et cetera. (Sampson.) This is not always the case, for small doses of X-rays have retarded the favorable progress in a small series of patients with defective hearing who had done unusually well on diathermy and negative galvanic treatment. There is no question, however, of the increased effectiveness of the X-rays when used with the ultraviolet rays. Sampson stated that while the X-ray alone, or ultraviolet alone, will clear up a condition, such as lupus, for instance, their combined use will attain much better results. In this we are fully agreed.

The X-rays attained considerable favor by some surgeons for the shrinkage of lymphoid tissue, and for the reduction of hyperplastic thyroids. X-rays have proved very satisfactory in tuberculous glands. The favorable results in this affection have been augmented by the additional use of ultraviolet rays. Scar tissue, especially of recent occurrence, is said to become disintegrated by the action of the X-rays. Keloids, too, sometimes disappear under X-ray therapy.

Skin affections which have resisted the older methods, and even the quartz-ray, sometimes rapidly disappear when only one or two X-ray treatments of small dosage are given. This is especially true in stubborn acne and intractable eczema, and in some parasitic affections.

Unfortunately, we are as yet in no position to give a final report on our work with small doses of X-ray in deafness. Sufficient time has not elapsed for final judgment. We have, however, reviewed the work of Richardson, Stokes and other authors, and we have quoted freely from their reports. The experiences of Witherbee, Denman and other clinicians, in conditions other than deafness, are striking, and excerpts from their published articles will be found in several of the following chapters.

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PART TWO

TREATMENT OF DISEASES OF THE EYE

CHAPTER VII

EYELIDS AND CONJUNCTIVA-LACHRYMAL APPARATUS

General Remarks.—The treatment of diseases of the eye with electrophysical agents is to be regarded as a step forward, for cures by the older methods were attained at the expense of time and energy. There are many diseases of the eye that probably never will lend themselves to treatment with electricity, and there are many conditions for which electrotherapeutic methods are of but auxiliary value. It is certain, however, that by the use of physical agents, properly applied, a substantial improvement in therapeutic results may be anticipated.

Hordeolum.—Radiant heat-light is the agent indicated. After twenty minutes exposure to the incandescent lamp, the stye is cauterized with the point of a sharp applicator, dipped in 95 per cent phenol solution. This is followed with a small alcohol swab. One or two treatments usually suffice for the average case. If a refractive error is at fault, properly fitted glasses should be prescribed, otherwise recurrence of the stye is common. Indiscretions in hygiene and impaired general health are other etiologic factors which frequently require correction.

Dermatoses of the Lids.—Eczema, herpes, and other skin affections usually occur at a time when other parts of the body are similarly involved. If the affection is entirely local in character the ultraviolet rays will prove of value. Three or four treatments with the water-

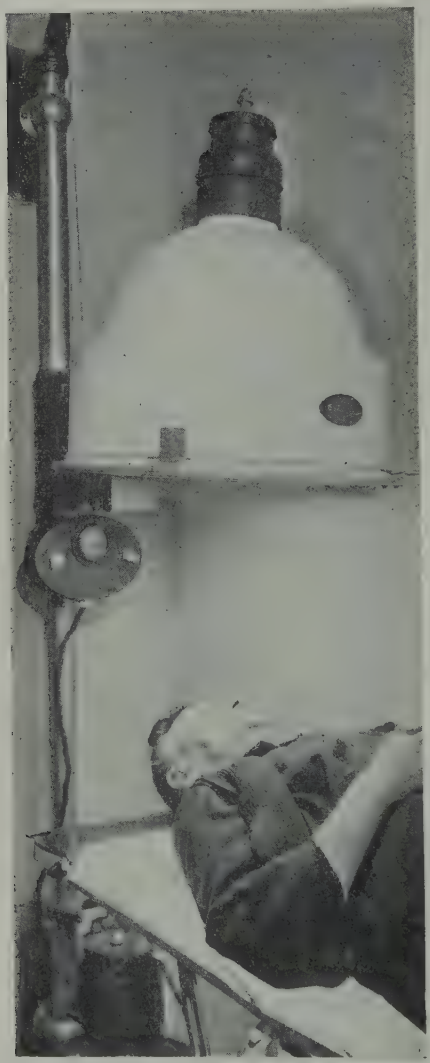

Fig. 36.—Treating conjunctivitis with radiant heat-light.

cooled lamp usually suffice, and these for very short intervals on alternate days. (One minute for every inch from skin.) Avoid the use of ointments or irritating soaps during this therapy.

Acute Conjunctivitis.—After removal of the immediate cause, active treatment by means of the radiant heat-light (Fig. 36) is instituted. Treatments should be frequent, twice or thrice daily, if possible, and each séance should last no less than twenty minutes. It is remarkable how quickly an acute conjunctivitis will respond to this single agent. Pain and discomfort are promptly relieved after the first exposure, with subsequent retrogression of the inflammation. The pa-

tient should keep the eyes closed while under the lamp.

The situation is entirely different when we are to treat an acute conjunctivitis of a specific type, especially gonococcal ophthalmia. This serious infection calls for cold applications, collyria, and other medicinal remedies as indicated. Radiant heat-light is simply an adjuvant to other well-known procedures.

Chronic Conjunctivitis.—The *palpebral* type is stubborn to treatment, but good results have been reported with the use of X-rays. The dosage is necessarily small and the intervals between treatments depend on the progress made. Sometimes positive galvanism works successfully when other methods fail. The *phlyctenular* type of conjunctivitis yields more readily, and should be treated with the high-powered incandescent light at daily intervals. Exposure should be of thirty minutes duration. Eye medication is employed as usual. Chronic conjunctivitis frequently yields to ultraviolet radiations from the water-cooled lamp. The technic is similar to that employed in the treatment of trachoma.

Vernal Catarrh.—Some investigators in this country and abroad consider vernal catarrh as a local manifestation of a constitutional derangement. Therapeutic tests seem to substantiate this belief, although no conclusive evidence is available. *Afenil,* administered intravenously, for its calcium action, is said to be of decided benefit. This would tend to indicate that the disease is influenced by some error in calcium metabolism, probably a blood calcium deficiency. The best plan is to use both local and general measures. One should apply

ultraviolet light by means of the water-cooled lamp to the everted lids and irradiate the body with the air-cooled lamp. The administration of thyroid extract, one-fourth grain, and calcium lactate five to ten grains before meals, three to four times daily, is helpful. When the symptoms abate, the medication may be given but once or twice a day. The light treatments are administered on alternate days. We have not found it expedient to employ intravenous medication and, therefore, do not advocate its use.

It would be interesting to determine the blood calcium content and basal metabolic rate of a large series of cases of vernal catarrh. Our own experience is too limited to enable us to present conclusions.

Trachoma.—Metallic cataphoresis has been used for the treatment of trachoma for many years. Neiswanger claims priority for this method. The positive pole of a copper electrode is used with a current of three milliamperes for ten minutes. The eye is first anesthetized with cocaine solution or some other local anesthetic, such as butyn.

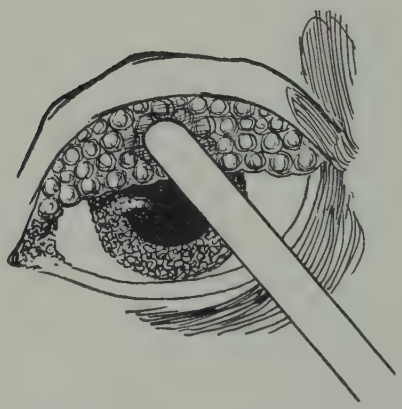

Fig. 37.—Applying the quartz ray to trachoma.

Coleman, in 1903, suggested the use of X-rays for trachoma, and at that time reported a series of thirteen cases, twelve of which were successfully treated. Since then various changes in technic and newer methods have been suggested.

In the very acute stage, the use of the high-powered incandescent lamp at close range, to the point of tolerance, several times daily, is recommended. As the disease becomes subacute, quartz light (Fig. 37) is indicated. It is essential to produce marked reaction, for without it good results cannot be expected. The treatments are given daily. The compression method (Fig. 38) is superior to any other, although some prefer to leave a space between the lid and the applicator.

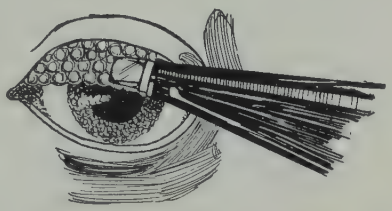

Fig. 38.—Compression method with quartz prism applicator.

In a few cases in which conservative plans were not sufficiently effective, X-rays and ultraviolet light, at alternate sittings, produced relief from all symptoms. The use of the high frequency current has not given successful results in trachoma, many investigators reporting complete failures with this procedure.

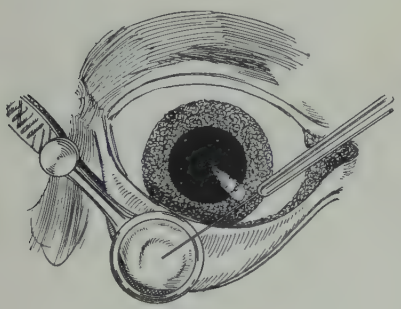

Fig. 39.—Electrodesiccation of chalazion.

Chalazion. — Ultraviolet light by compression on the conjunctival side is sometimes of value. In stubborn cases electro-desiccation is employed. A needle electrode (Fig. 39) is thrust into the swelling by way of the conjunctiva, and the current turned on sufficient to produce a moderate swelling. Or electro-desiccation may be utilized after the chalazion has been incised and curetted. Surgical diathermy

insures the complete destruction of the lining of the chalazion and thus prevents recurrence.

Pterygium.—After anesthesia, the growth is pierced by a needle electrode near its base and destroyed by electro-desiccation. The part extending to the cornea can now be dissected or destroyed by further desiccation. If the pterygium extends over the cornea, it is advisable to first dissect the growth free and then coagulate its base, using the D'Arsonval current. The base of the growth may be destroyed with positive galvanism.

Malignant Tumors.—Epitheliomata, rodent ulcers, and sarcomata, are treated successfully with surgical diathermy alone, or with X-ray and radium emanations. For small tumors, diathermy is without equal, for there is a minimum production of post-operative disfiguration. The combined methods of surgery, X-rays and radium are sometimes best suited for large new-growths, or any of these procedures may be used after electro-coagulation. Rodent ulcers sometimes respond unusually well to zinc ionization.

Angiomata.—These may be destroyed with positive galvanism, using a needle electrode within the growth. When the tumor is small, compression ultraviolet irradiations may suffice. In severe cases, surgery and surgical diathermy may have to be employed as a last resort.

THE LACHRYMAL APPARATUS

Stenosis of the Naso-lachrymal Duct.—Jarecky has devised a set of special dilators or probes, with which he employs the negative galvanic current. By means of dilatation (Fig. 40) and simultaneous electrolysis (Fig. 41) repeated at intervals, until the strictures are completely overcome, the stenosis can be permanently

relieved. The method described has not been thoroughly tried in this country, probably because of the difficulties in procuring the correct type of dilators for electrolytic therapy In dacryocystitis, the above technic should be adopted except that positive copper dilators are used as the active electrode. Snow advocates the use of vacuum eye-electrodes with the static current when the tear duct is closed, but not stenosed.

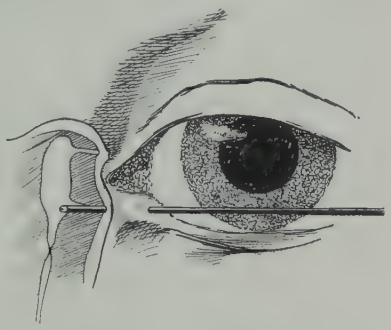

Fig. 40.—Dilatation of lachrymal duct.

Results with electrotherapeutic measures in affections of the lachrymal apparatus have not been consistently good. The source of infection is often overlooked. If a chronic ethmoiditis is at fault, proper surgical measures must be employed for its correction. When stenosis is present, galvanism is a logical procedure, which properly applied in conjunction with other treatment, not necessarily electrotherapeutic in character, will afford favorable results.

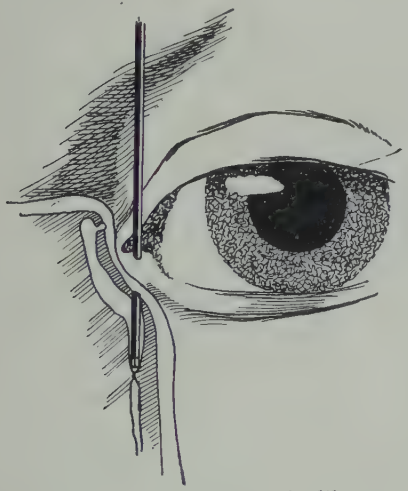

Fig. 41.—Electrolysis with dilator in position.

Dacryocystitis.—

Friel recommends ionization and gives the following technic: The sac should be washed out with a zinc sulphate solution, and the current conveyed to the cavity by means of the platinum needle of a syringe insulated on the outside with celloidin or shellac. A piece of rubber tubing connecting the outer end of the needle with a funnel filled with zinc solution, will suffice for the distention of the lachrymal sac with the fluid.

CHAPTER VIII

CORNEA, UVEAL TRACT AND RETINA

Corneal Ulcer.—The establishment of the cause or causes of corneal ulcer should precede treatment. Elimination of foci of infection and correction of systemic disorders are important. Many ulcers are due to infection of dental origin, requiring preliminary dental care. Tuberculosis or syphilis should always be inquired into and corrected on established principles.

Several methods of treatment have been recommended. Atropin is used from the very outset. If cauterization is indicated, electrodesiccation is preferable to the older methods. Negative galvanism over the lids (Fig. 42) stimulates repair. In ulcers which require no cauterization, the use of atropine and radiant heat-light suffices. The eye should be kept covered in the intervals between treatments.

It is claimed by several enthusiastic workers that quartz ray therapy rapidly sterilizes corneal ulcers. While this has not been incontrovertibly established, ultraviolet radiation is indicated on general principles and can be employed without in the least affecting or interfering with any other methods of therapy that one may desire to employ.

Birch Hirschfeld of Berlin has treated 531 cases of infectious diseases of the cornea in a period of six years. The first cases under treatment were ulcers of the cornea,

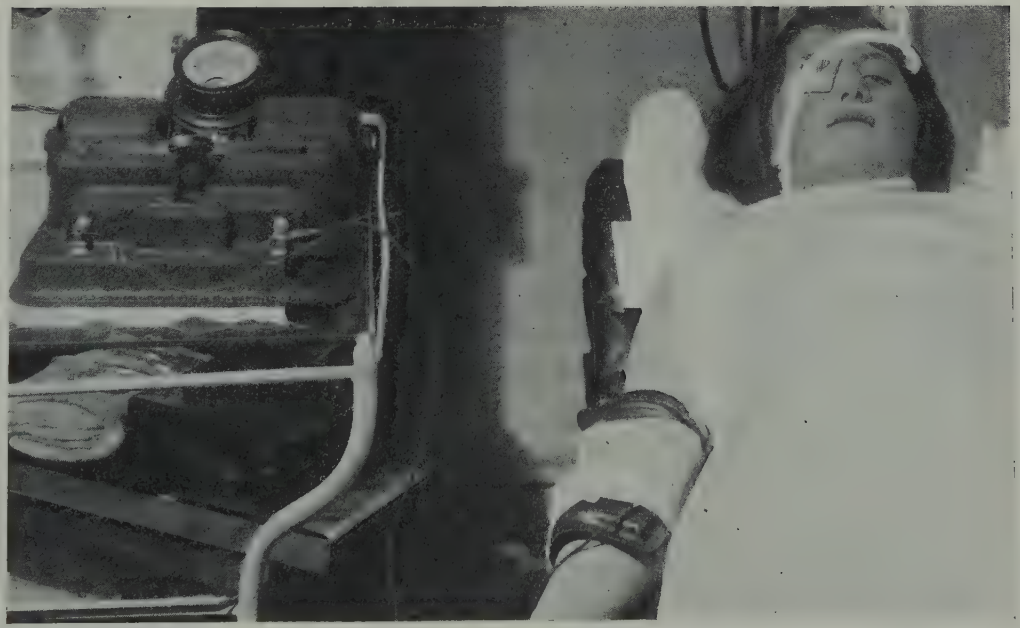

FIG. 42.—Negative galvanism over lid.

mostly serpiginous in character (281 cases) with positive pneumococcus findings. Generally, improvement occurred after a few irradiations. The average duration of treatment was two weeks with two daily irradiations for five or six minutes; aside from this only atropin and hot compresses were used. Only 24 cases could not be arrested. The others reacted more or less rapidly, although some small superficial ulcers and a few deep infiltrating ulcers remained stubborn. The treatment was painless and no injuries of the lens or eyeground were observed. The scars were very delicate and rarely did a case terminate in perforation, ectasis of the scar, or secondary glaucoma. Recovery was effected in 92 per cent of the cases of serpiginous ulcer. The irradiations proved excellent also in diplobacillary ulcer (22), ulcer in pannus (48), marginal ulcer (30) and stubborn scrofulous ulcer (45). Superficial keratitis and freshly infected injuries of the cornea responded well. The results were less favorable in deep, interstitial and tuberculous keratitis and episcleritis.

Denman believes that ultraviolet rays act by coagulation of the bacterial protoplasm. His technic is as follows: The water-cooled quartz burner lamp, with the small quartz rod extension (3mm. thick, 2½ in. long) is utilized. The top of the rod is directed on the infected area, not in contact, but 3-4 millimeters away. The axis of the rod should be at a right angle to the surface of the area treated. The time is 45 seconds to 1 minute. The patient feels neither heat nor any other sensation. Treatment is repeated each day, but usually one to three applications suffice. Delayed replacement of the destroyed corneal tissue is hastened by the stimulative dosage of the diffused rays at a longer distance. This is

usually done with the water-cooled lamp without condenser, but the air-cooled lamp may well be used through the diaphragmed fenestrum, to prevent including the whole face.

Zinc ionization has been successfully employed for corneal ulcers. The technic consists of anesthetizing the eye with cocain solution, cleansing the ulceration and applying a pad of cotton, saturated with weak zinc solution, attached to a zinc rod and pressed against the ulcer. A current of 1 ma. is used for five minutes.

The treatment of so-called infected ulcers has proved somewhat of a problem, although it is now claimed that the electrothermophore is of decided benefit in these conditions. Shanahan in 1917 reported thirty-two cases of serpigenous ulcer of the cornea, hypopyon keratitis of pneumococcus origin, treated with his thermophore, in which the results have been very favorable.

Young gave the following technic of thermophore treatment: 5 instillations each of two per cent butyn adrenalin 1:1000 at two minute intervals, under which condition the procedure is entirely painless.

The thermophore is set for the desired temperature, an applicator point is inserted in the instrument and permitted to remain heated for several minutes to insure the proper temperature of the applicator.

A speculum is inserted and the conjunctiva is grasped with fixation forceps to steady the globe, while the thermophore tip is applied directly and somewhat firmly to the diseased area for the required length of time.

In selecting the size of the applicator, one somewhat smaller than the size of the ulcer should be used, as the cornea is affected for a distance of about one millimeter in all directions from the periphery of the applicator.

For an ulcer 4 millimeters in diameter, an applicator tip of 3 millimeters in diameter is sufficient.

When the ulcer is large and has a definite advancing, undermined arc, it usually suffices to apply the instrument to the advancing edge or arc of the ulcer, in which case it may be necessary to apply the instrument to some other portion of the ulcer in 24 to 72 hours, as shown by progressive areas.

To stop the progress of an ulcer, high temperatures are used, directly applied to the lesion. One application is usually all that is required to effect a cure.

To stimulate regression and absorption, lower temperatures should be used. This is attained by holding the applicator at a little distance from the ulcer.

Young believes that the thermophore is virtually a specific in the treatment of so-called infected corneal ulcers, relieving pain, stopping progress, and insuring the best possible visual results.

Interstitial Keratitis (Syphilitic).—Doses of one-fourth of a Holzknect unit of X-ray at six weekly applications have been employed by Japiot and Bussy. Early treatment before the period of vascularization, acts by aborting the process and bringing about a *restitutio ad integrum*. Their conclusions are: (1) irradiation gives the best results in heredospecific keratitis, less in that of uncertain etiology, and least of all in scrofulous infants; (2) the X-ray acts better in the inflammatory form with active congestion of the anterior segment and intense subjective symptoms, than in the torpid form; (3) the younger the patient the better the results; (4) treatment should be begun as early as possible; when instituted during the first few weeks it may actually abort the disease; (5) one of the characteristic effects of irra-

diation is cessation of pain and prompt disappearance of photophobia and blepharospasm; (6) in untreated keratitis the regular stages of evolution are infiltration, vascularization, and reabsorption; in those treated from the onset vascularization is always absent or is seen only in a few discreet vessels at the periphery of the cornea.

Two cases are reported by de la Vega who employs thirty per cent of the erythema dose filtered by two millimeters of aluminum, giving one treatment every three weeks until five or six are given in all. He believes that X-rays are beneficial in interstitial keratitis at any stage, being especially serviceable in resolving the deposits produced by this disease on the cornea. The results of the initial applications vary according to the early or late stage of the disease. General treatment must be carried out at the same time in addition to the topical measures.

Interstitial Keratitis (Tuberculous).—Edgar Mayer and his associates produced an experimental bovine tuberculosis of the cornea in rabbits and irradiated it with quartz mercury light alone, or in combination with certain sensitizing substances, chiefly dyes, directly applied to the lesions. The results gave distinct evidence of the marked differences in the treated eyes as contrasted with the controls. Variations in response, according to Mayer, occur with different exposures and the different sensitizing substances employed.

This experiment has practical application. Several patients, principally children, have responded well. General ultraviolet irradiations were employed in addition. Mayer makes an important point, commonly overlooked by ophthalmologists prone to depend almost entirely on local measures. "It seems imperative in all

forms of tuberculosis to which light is applied to combine both general and local irradiation. It has been shown that healing takes place in 30 per cent more of cases of lupus vulgaris when general body irradiations are used in addition to local exposures." (Mayer.)

Iritis—Cyclitis—Irido-Cyclitis.—One should determine whether the inflammation of the iris is primary or secondary, and whether it is a local affection or a consequence of some general disease. Syphilis and tuberculosis must always be borne in mind, although many patients give a history of rheumatism or other conditions which tend to indicate the presence of metabolic disorders.

The local treatment of iritis represents only one avenue of attacking the disease, unless it be purely local in character. Local therapy must be supplemented by general measures based upon the underlying etiology.

The use of electrotherapeutic agents for iritis almost always answers the need of local treatment. If some metabolic disturbance exists, this often can be favorably influenced by general ultraviolet irradiations. These are of decided advantage also in some cases of tuberculosis, in rheumatism and in diseases influenced by alterative treatment.

Much of what has been said on corneal ulcers applies also to iritis. Corneal ulcers not infrequently occur with a complicating iritis and nothing should be used for one which would aggravate the other. Active hyperemia calls for ice or cold packs. Atropine should be used promptly. When the active hyperemia has become passive, radiant heat-light should be applied by means of a 1500-watt incandescent lamp at least once daily, for thirty minutes, if the patient comes to the office. If the

patient is confined to bed, the lamp treatments should be given two to three times daily.

The high frequency currents have been advocated because of their ability to promote reparative processes, to stimulate phagocytosis and to increase elimination. Caution must be exercised in their application, and they should be used only in selected cases. They are not advocated as a routine measure. If pus is retained in the eye, diathermy is definitely contraindicated.

Atropine, radiant heat-light, after the acute hyperemia has subsided, and general ultraviolet irradiations, have served our purpose in the majority of cases.

Rest, elimination and regulation of hygiene in general, are essential for good results, irrespective of the methods of treatment instituted. Details will depend upon careful consideration of the history, laboratory tests and the presence of symptoms which require prompt relief.

Choroiditis.—In this affection there are usually no external evidences of inflammation or pain. "The eye looks normal externally, and the disease manifests itself to the patient only through disturbance in sight, and to the physician only through ophthalmoscopic examination. But if the disease passes over the anterior portion of the uvea, it becomes recognizable exteriorly through the symptoms of cyclitis and iritis (irido-choroiditis)." (Fuchs.)

The treatment with electrical agents is similar to, and the contraindications practically the same as described under iritis. Diathermy is absolutely to be restricted to the *non-suppurative* type of choroiditis. Constitutional therapy when indicated is of foremost importance. "Local agents should aim to produce rapid resorption of the exudate in the choroid and the retina, and also in

the vitreous." (Fuchs.) This is best accomplished by galvanism, radiant heat-light and general body irradiations with the air-cooled quartz lamp. Proper hygienic measures are essential.

Galvanism is indicated in *suppurative* choroiditis and occasionally proves of considerable value.

Retinitis.—Electrotherapy is contraindicated in the acute stage. The hemorrhagic form, which is commonly associated with hypertension, requires rest in bed and appropriate therapeusis. Later, high frequency currents should be applied. An improved technic for applying direct diathermy to the eye is illustrated in Fig. 43. Daily treatments should always be given preferably by the physician himself or by a trained assistant under his direct supervision.

FIG. 43.—Active electrode in position for treating the eye.

Retinitis may coexist with choroiditis. So-called choroid-retinitis is the result. The general care and treatment advised for retinitis apply to this affection as well.

Episcleritis.—The X-ray is considered the best therapeutic agent. Numerous exposures are necessary. Palliative effects may be obtained in scleritis and episcleritis with the therapeutic lamp, but relief is only transitory. Too much should not be expected from electrotherapy in these conditions. Negative galvanism, with the pole saturated with chloride of sodium, and applied to the closed lids, has proved successful. Emphasis must be laid on the necessity of constitutional treatment.

Leduc reports success with negative galvanism according to this technic: The anode is applied to any suitable

part of the body, and a tampon electrode covered with several thicknesses of absorbent cotton, impregnated with a warm solution of sodium chloride, is applied and kept for a quarter of an hour on the upper eyelid. The eye being shut, the strength of the current is gradually raised to 5 or 6 ma., and two or three séances are given weekly. The pain subsides, the granulations and vascularization of the sclerotic disappear, and complete recovery rapidly ensues.

CHAPTER IX

OPTIC NERVE

Diseases of the optic nerve constitute a group of affections for which therapy has been of little avail. The determination of the exciting and predisposing etiologic factors is usually very difficult, rendering prognostic deductions uncertain.

Anatomically, the optic nerve may be divided into three parts, the *intraocular,* the *orbital,* and the *intracranial.*

The first portion of the nerve enters the eye through the scleroticochoroidal canal. The fibres at this point are traversed by numerous connective tissue septa, the lamina cribosa, which is the weakest spot in the eye and the first to give way in increase of ocular tension. The nerve fibres in the lamina cribosa are surrounded by nonresilient, tough connective tissue fibres, a condition which does not prevail in any other part of the nerve, and it is here that constriction and strangulation of the nerve most frequently takes place.

The *orbital* portion extends from the eye to the optic foramen and is S-shaped. In other words the length of this part of the nerve is greater than the distance which separates the eye from the foramen. On this account the posterior pole of the eye is normally freely movable, while in inflammations of this portion, movements are painful and at times almost impossible. The sheaths of

the nerve are continuous with those of the brain, and the spaces between them are occasionally the site of accumulation of fluid.

The *intracranial* part starts in the short bony optic canal, where it may be compressed easily by inflammation or changes in the bony wall.

The nerve passes to the optic chiasm, flattened and covered only with the pia. The fibres of both nerves decussate here and pass on to the subcortical and cortical centers.

A great variety of diseases may affect the optic nerve in all or in some of its divisions, and cause changes varying from simple hyperemia to primary or secondary atrophy, or merely subjective symptoms, as in toxic amblyopia. The latter state may occur acutely, as in alcohol poisoning, or chronically, as in poisoning with nicotine and alcohol. The causes of objective changes in the nerve are given by Fuchs in the order of their importance, and may be tabulated as follows:

1. Brain diseases.
   (a) Tumors.
   (b) Abscesses, thrombosis of sinuses, aneurysms, apoplexies, and cysts.
   (c) Disseminated sclerosis, acute and chronic meningitis, and hydrocephalus.
   (d) Spinal cord disease.
   (e) Injuries.
2. Syphilis.
3. Acute infectious febrile disease, chronic disturbances of nutrition, and poisoning especially by lead.
4. Acute anemia.
5. Heredity.
6. Orbital affections, such as inflammations and tumors. (It should be noted that in children the usual causes are tubercles, meningitis, and hydrocephalus.)

The essential nerve changes begin with edema and cellular infiltrations of the perineuritic connective tissues. The pathologic changes penetrate deeper into the nerve, by extending along the connective tissue septa which surround the nerve fibres and which are actually continuations of the perineurium. After the acute inflammation subsides, there occurs a contraction of the newly formed tissue, which results from the cellular infiltrate about the nerve fibres. Atrophy may be produced in this way.

It is well known that involvement of the optic nerve is frequently a manifestation of some systemic organic disease. Treatment directed to the nerve only, is purely symptomatic and without effect on the underlying cause. In an idiopathic case or when the etiology is obscure, local treatment is justifiable. The same holds true after other therapeutic measures had been tried without success, and symptomatic relief is sought. In virtually all instances treatment directed to the optic nerve is indicated during and after treatment of the primary disease.

Two measures are indicated for the alleviation of optic nerve affections apart from care of the causal disease. These are diaphoresis generally, and the application of heat locally. These measures are beneficial because of their effects on elimination and circulation and the secondary changes which they produce.

The usual means of producing diaphoresis, namely, by hot packs, electric light baths, hot water bottles, hot drinks, pilocarpin hypodermically, and by means of other drugs generally, may be employed. Autocondensation for fifteen minutes with a current of 700-1000 ma. produces a satisfactory diaphoretic action. A cathartic, such as castor oil, should be administered at regular intervals

to insure adequate removal of intestinal end products. With close observation of the pulse and blood pressure, autocondensation may be repeated daily. Precautions must of course be taken with regard to dry clothing and exposure to cold after treatments.

To apply heat effectively to the optic nerve is not a simple matter. The nerve lies at a depth of one to two inches from the nearest surface and is approached most directly through the lids. An attempt to heat the nerve by way of the lateral wall of the orbit meets with less success. The loose areolar and fatty tissue of the orbit is well supplied with blood vessels and therefore disperses rather than conducts heat applied to the skin of the lids. Furthermore, heat applied by hot dressings, radiant lamps, and the like is lost to a very great extent by radiation and surface conduction.

It is therefore necessary to use a maximum tolerable heat at the surface to produce a slight rise of temperature in the region of the optic nerve. Heat is indicated on the basis of the existing pathology. Reference to the animal experiments in the appendix will show this relation in still another way. In tests with diathermy, therapeutic temperatures within the orbit were obtained with minimal surface heat and with an easily tolerated current of medium voltage and low amperage.

Theoretically, diathermy should lend itself most effectively as an excellent means of administering heat about the optic nerve. Clinically, it has been found of very great value when used properly, the technic of application being of utmost importance.

The D'Arsonval current is used. A metal electrode (Fig. 43) is warmed and moistened with soap solution and fitted over the closed lids. Moderate but firm pres-

sure is exerted. The indifferent (larger) electrode is similarly prepared and placed over the nape of the neck (Fig. 44) and firm pressure applied. To ensure good contact of the electrodes, the skin surface may be lubri-

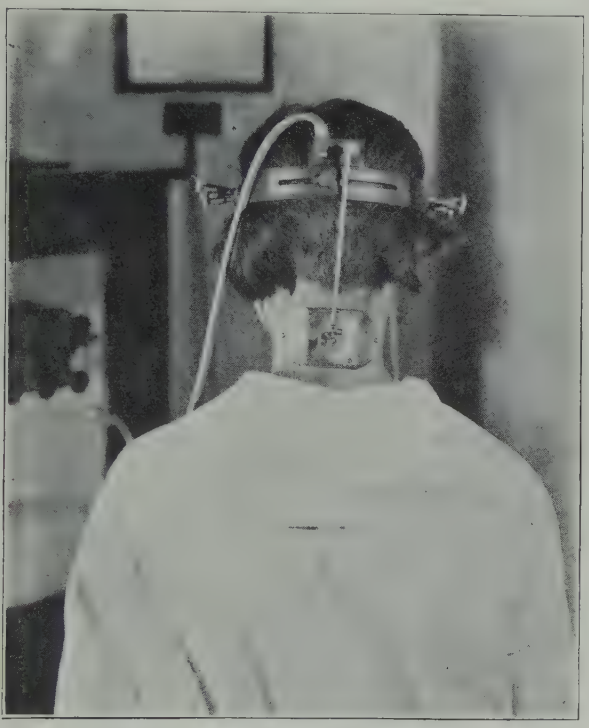

Fig. 44.—Site of indifferent electrode.

cated with any desired gelatinous substance. Thus deepest heat generation without surface sparking and other discomforts are reasonably assured. The current is turned on very gradually, reaching its maximum strength in about five minutes. The time of a single treatment is 30 to 40 minutes, which should be repeated at inter-

vals of twelve to twenty-four hours, depending upon the severity of the symptoms and the progress made.

In acute cases diathermy to the eye may be preceded by radiant heat-light for fifteen to thirty minutes. All treatments should be followed with some form of galvanism or the sinusoidal current. We believe negative galvanism or the surging sinusoidal to merit consideration as after-treatment. It is probable that the sinusoidal current stimulates the vasomotor circulation, thus aiding the nutrition of the nerve tracts.

There should be some amelioration of symptoms after a short course of treatment, but a long period is usually necessary to bring about results if they can at all be secured with the measures described.

In acute mild cases we have observed a prompt return to normal vision with diathermy in less than the usual time required by other methods. In cases of longer standing, we have never seen a marked improvement of vision. But in these patients specially selected for diathermy treatment, prompt alleviation of headache and pain in the eye was the rule. The pain and discomfort accompanying ocular movements are relieved as well.

It is generally recognized that the prognosis of optic neuritis has not been good, in spite of any treatment heretofore advocated. Our experience has been that individuals who were treated with diathermy showed a retardation of the progress of the disease, and always an improvement of subjective symptoms other than visual.

In combination with approprite medical and surgical care, diathermy offers an important addition to the management of optic nerve disease. We feel assured that further experiences will substantiate this view, provided the cases chosen for treatment are thoroughly studied.

CHAPTER X

VITREOUS OPACITIES—CATARACT—GLAUCOMA

Vitreous Opacities.—The causes of opacities of the vitreous are generally exudates deposited in the course of inflammations of the uvea or retina; but hemorrhages, taking place from the vessels of these membranes into the vitreous, either spontaneously or as a result of injuries, may also give rise to opacities of the latter.

Recent opacities may be absorbed with resultant clearing up of the vitreous. Some writers advocate systemic diaphoresis, and this is helpful in many instances. Focal infection, especially with reference to teeth, tonsils, nose and nasal accessory sinuses should be promptly and thoroughly removed, if favorable results are to be obtained from any method of treatment. Corrective measures for elimination, dietary régime and absolute mental and physical rest, are valuble and greatly aid the effectiveness of general treatment.

Much work with galvanism has been done in an effort to accelerate absorption of the opacities. Our own efforts have not been uniformly successful. Galvanism should be employed in conjunction with the measures suggested above, but requires patience. Good results have been reported from its use independent of other treatment.

Direct diathermy has proved effectual in some cases. The treatments must be administered daily, or at least on alternate days. Care must be exercised in the application of the electrode. It is unnecessary to use a milli-

amperage exceeding 200. When hypertension due to arteriosclerosis is known to be present, autocondensation treatments are indicated. Metabolic disorders may be adequately treated with the actinic rays. General irradiation of patients with vitreous opacities is now routine in our practice.

Cataract.—It is well established that no medicinal treatment is effectual against cataract, but the electrical currents hold out some hope in selected cases. Negative galvanism merits a thorough trial. Daily operations over a long period are necessary, and persistency in this regard will often be rewarded by results. The high frequency currents, too, should be given a trial. Use may be made of the improved eye electrodes for this purpose. With diathermy also persistency is necessary. No claim is made that cataracts can be cured by electrical currents, nevertheless, eye surgeons have recognized that some of the electrical currents prove successful in some incipient cases.

The administration of calcium salts and thyroid extract has been recently suggested an an adjunct in the treatment of incipient cataracts. These remedies may be beneficial to patients in whom an etiologic indication has been established. General radiations with the ultraviolet lamp are now employed for obvious reasons.

Too much emphasis cannot be laid on the importance of eradicating every focus of infection which can be detected. Systematic elimination will deter the rapid progress of a cataract in many patients.

Diabetes, syphilis and other diseases which may act as direct or indirect causative factors, require specific treatment.

Cataracts, other than those incipient in character,

should not be treated with physical agents, until further experimental work with electrotherapeutic methods conducted by many investigators shall throw more light on this important subject.

Harris advocates electrotherapy, rest and exercises in the treatment of cataract. His technic embraces pneumomassage by means of a small pump giving suction with release (1-1¾ in. stroke, 60-600 vibrations per minute) for three minutes; high frequency for seven to ten minutes; constant current (3-10ma) ten to fifteen minutes (changing once a week or oftener, according to conditions, from the constant current to the galvanic sinusoidal); palming thirty minutes three times daily; flashing and swinging, both for "far" and "near," as often as possible; vibration of the third, fourth and seventh cervical vertebrae with a hard vibratode for three minutes. The patient must be taught to apply palming, flashing and swinging himself, and he should continue these exercises at home. The duration of the course of treatment varies from three months to two years.

Harris briefly reports eight illustrative cases. He is convinced that incipient senile cataract can usually be cured in this way. In cases of long standing without choroidal changes, the vision can be improved, and the disease arrested and occasionally cured.

Glaucoma.—Increased intraocular tension occurs as a primary disease or secondary to another, such as iridocyclitis or choroiditis. The causes of plus tension in primary and secondary glaucoma may be identical, *viz.*, an alteration in the cellular contents of ocular secretions; generally, however, the ocular causes of secondary glaucoma are quite obvious, *e.g.*, iritis, anterior synechiæ, retinal hemorrhage, etc. Primary glaucoma usually pre-

sents no discernible etiology, but is found to be associated with a great variety of local and general pathologic changes. Among these are loss of vasomotor control in the body or in the eye, anatomical changes in the eye, such as thickening of the fibres in the pectinate ligament, blockage of channels of outflow by products of autogenous toxemia, and alteration in the quantity and quality of secretions.

Treatment must be individualized. Glaucoma may be classified clinically according to symptoms, but it is almost impossible to arrive at a classification on a pathological basis, *in vivo*. All medical and surgical treatment should be directed to reduce intraocular tension by reëstablishing or reënforcing the outflow of the ocular fluids. Most operations have for their object the elimination in part of the filtration angle and the production of a fistulous tract, through which secretions may seep into the subconjunctival tissues. The object of medicinal treatment is to produce miosis and to stimulate the outflow of fluids by changing their character and altering the blood circulation (venesection or dionin instillations). In primary glaucoma, many systemic deficiencies must be corrected; in secondary glaucoma, the causative disease requires therapy, the nature of which often is diametrically opposite to that for the glaucoma.

One can readily appreciate the reasons for the frequent failure of all treatment to prevent or arrest progressive loss of vision in this dreaded malady.

In selected cases galvanism and diathermy may prove of inestimable value. Le Prince, in France, and Humphris, in England, have used negative galvanism over the eyes in glaucoma, and have reported that pain has been lessened and tension lowered as a result of its use. Cer-

tain authors claim to have obtained good results with diathermy, but thus far their results have not been confirmed by competent observers.

We have attempted by animal experimentation to establish a rational basis for the use of diathermy in glaucoma. The great difficulty connected with the artificial production of glaucoma has hampered our investigations.

We have studied the effect of diathermy on intraocular tension by the Schiotz and Gradel-Schiotz tonometers. In the normal eye there is a lowering of tension following the administration of diathermy for one-half hour. This lowering is not due to the response to external pressure over the eye, as pressure alone over the untreated eye was used as a control. Negative galvanism applied over the eyelids with moderate pressure produces a lowering of tension in some cases. The tension in normal eyes returns to normal in 5-10 minutes.

Glaucomatous eyes do not uniformly respond to electro-physical measures, owing to the fact that physical agents cannot be rationally applied on a pathologic basis in all cases. Relief from pain may be anticipated, but the lowering of tension is not always assured. There is occasionally a tendency toward increase of tension after administration of physical measures, but as a general rule, the ultimate effect has been favorable. We advocate the use of diathermy and galvanism subject to the following restrictions.

The use of these agents is indicated, in addition to the customary treatment, in early cases where emergency surgery is not called for. In all cases of persistent high tension, resisting medical and surgical treatment, diathermy and galvanism should be tried. Painful abso-

lute glaucoma may often be ameliorated with diathermy alone, and enucleation thereby avoided. *Prophylactically* these measures may be found of great value in two instances: in the intervals between attacks, and second, after operation when adequate healing has occurred.

The application of both diathermy and negative galvanism is made over the closed lids as previously described. While direct diathermy with metal electrodes is preferred, non-vacuum electrodes may be employed with equally good effect. During the first week all treatments must be preceded by a measurement of the tension in both eyes. Immediately after the treatment and also two hours later, the tension must again be measured. These measurements not only serve as an index to the effect of diathermy or galvanism (or both) but also help to establish a rational basis for continued treatment. In our experience, cases which have responded well to diathermy offer the best prognosis. Certainly there are no untoward results from physical therapy.

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PART THREE

TREATMENT OF DISEASES OF THE EAR

CHAPTER XI

THE EXTERNAL AND MIDDLE EAR

Furunculosis.—The treatment of furunculosis of the external ear has at times been discouraging. Reich a long time since advocated air heated to 100° to 120° C., applied two to three times daily, with which he obtained good results. It was thought that the hot air reduces the virulence of the staphylococci and produces hyperemia, resulting in absorption of the infiltration.

During the past few years, vaccines have found many adherents. Both the stock and autogenous vaccines have been employed with some success, especially when used in conjunction with local treatment.

In general, it may be said, however, that vaccines have not been a method of choice in the treatment of ear furunculosis, and the use of physical agents for this condition has proved preferable. They quickly reduce the local infection, relieve the discomfort, and altogether are quite satisfactory.

Radiant heat-light should be applied for twenty minutes over the affected ear, after which the ear canal is packed very lightly with a narrow gauze strip, saturated with a 1-500 acriflavine solution. If the furuncle is easily accessible on the external ear, short irradiations with the water-cooled quartz lamp subsequent to the application of the high-powered incandescent light are quite serviceable, but not always necessary. As furunculosis of

any part of the body is frequently due to some metabolic error, general body irradiations with the air-cooled quartz lamp serve as a valuable adjunct to the local treatment.

Eczema.—The etiologic factor should be removed. Radiant heat-light applied twenty minutes and followed by exposure to the air-cooled quartz lamp at close range, on successive days, will prove effective in the acute cases. For the subacute and chronic eczemas, the blistering effects obtained by the use of the water-cooled ultraviolet lamp are necessary. It is not essential to precede application with the water-cooled apparatus by radiant heat-light. (Fig. 45.)

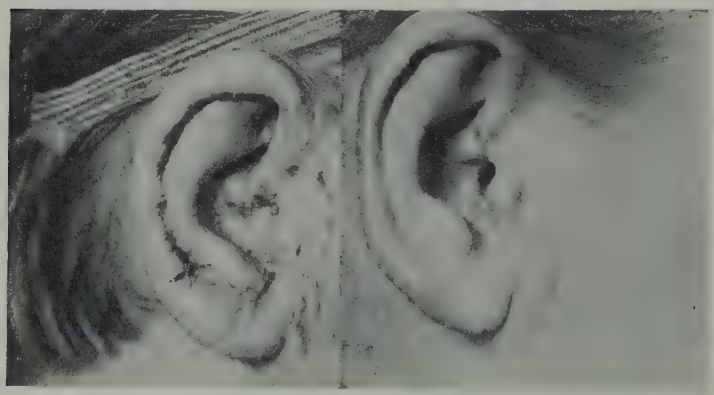

Fig. 45.—Eczema of fifteen years' duration, before and after treatment with ultraviolet light.

Hygienic and dietary measures should be employed, but the use of ointments and other medicaments is incompatible with electrotherapeutic agents.

Acute Otalgia.—The usual prescription is either 5 per cent or 10 per cent warm phenol-glycerin to be instilled into the ear canal. This may relieve, but frequently it

does not. If the instillation of the phenol-glycerin is followed by twenty to thirty minutes' irradiation with the radiant heat-light, complete relief is very often obtained and complications will be averted. It may be necessary to repeat the séances several times. Pain and discomfort diminish, and the inflammation usually subsides. If a sore throat or some acute nasal infection is present, these should obviously be treated as early as possible.

Acute Otitis Media.—An otalgia may be the beginning of an abscess in the middle ear. The pathologic picture is well known. Radiant heat-light is the ideal treatment which is now quite generally employed by many otologists.

Gerstenberger and Dodge quote Oeken, who treated 258 cases: 50 cases of acute simple otitis media; 5 cases of perforative otitis media, with mastoid involvement; 2 cases of single mastoid opening; 50 cases of acute otitis media with exudate formation; 1 case of othematoma, and 100 cases of external auditory canal furuncles. Oeken used the heat rays in acute otitis media with exudate formation, by having the patients take two daily sittings of one hour each. The earache was lessened and in most cases the drum membrane cleared up in two or three days, the exudate was absorbed and the bulging of the membrane disappeared, paracentesis was avoided and the infection controlled.

Gerstenberger and Dodge have employed the same treatment in chronic suppurative otitis media, and as an abortive measure, early in scarlet fever and measles showing normal drum membranes, to see whether the development of otitis media in these diseases could be lessened. The observations were very favorable.

Our experience with radiant energy in the various types of otitis media extends over a large series of cases. We have limited its use to acute middle ear disease, with or without suppuration. Relief of the otalgia is prompt. The heat itself undoubtedly affords this relief by its sedative and decongestive action upon the nerve endings; yet, when one observes how strikingly prompt this is, one

Fig. 46.—Radiant heat-light in acute otalgia or otitis media.

is forced to accept that the penetration of the light rays is greater than is generally believed to be, and that the rays themselves have much to do with the relief of pain.

The action of the light rays on the affected structure and on adjacent structures arrests the inflammatory changes, limits the infective process and, in many instances, prevents complications, the most important of which is mastoiditis. Defective hearing is also a very

common complication which may occur even though the infection itself has been cleaned up.

Too much stress cannot be laid on the value of early treatment, because it is in the first stage of otitis media that we have the most favorable opportunities for arresting the disease and preserving the hearing.

The technic in detail is as follows: (1) the patient should recline on a low couch or table; (2) the lamp should be placed at about thirty inches from the head (Fig. 46) with the patient lying on the side opposite from that of the ear to be treated; (3) the time of exposure should be gaged by the distance between the lamp and the part irradiated. A good rule to follow is to allow one minute for every inch of space. If the lamp is thirty inches from the ear, the part should be exposed for thirty minutes; (4) at least one treatment daily is necessary; (5) the lamp should not be so close that the patient has to complain of too great heat, even once during a treatment; (6) the patient's eyes should be covered with colored glasses.

The following selected cases illustrate the striking effects of radiant energy: W. G., age 33, housewife, developed an acute otitis media after an attack of influenza. The ear drum was beefy red and the otalgia severe. The indications based on clinical examination and symptoms were for immediate paracentesis. The patient refused surgical intervention and, after being told of the possible dangers of mastoid involvement, submitted to light therapy. The radiant heat lamp was applied twice daily for thirty-minute periods. The otalgia was relieved after the first irradiation and, after four days, the acute symptoms had subsided to a considerable extent. In one week the ear drum returned to normal. No drugs were prescribed and no other local measures than the light were used until virtually all the acute symtoms had disappeared. The ear drum did not rupture.

E. R., schoolboy, age 6, suddenly developed an acute otitis media after a common cold. The parents did not seek medical attention until the ear drum had ruptured spontaneously and the discharge was profuse. Mastoid tenderness and pain were marked. Roentgenograms showed definite mastoid involvement, as compared with the normal ear. The question of mastoid operation was debated, but finally it was decided to enlarge the opening in the drum membrane and to apply radiant heat. The lamp was applied four times daily at a thirty-inch distance for half-hour periods. The canal was kept as clean as possible, by dry swabbing. In four days the discharge diminished, the mastoid tenderness lessened and the patient's general condition improved correspondingly. Within ten days the ear was practically dry. There was some impairment of hearing, which was subsequently treated by other methods.

R. E. W., male, age 4. Otitis media during course of scarlet fever. Discharge very profuse after spontaneous rupture of the drum. Distinct mastoid tenderness with little or no otalgia. Radiant heat applied three times daily for thirty-minute periods. Within one week the discharge was lessened to half the amount and in two weeks the ear canal was dry. During the second week the lamp was applied only once daily. No drugs were employed.

Chronic Purulent Otitis Media.—The varieties of treatment employed by otologists for chronic, purulent otitis media are classified as: (1) antiseptic; (2) suction; (3) aëration; (4) irrigation; (5) desiccation and pulverization; (6) zinc ionization; (7) vaccine; (8) radiant light and heat; (9) ultraviolet rays; (10) surgery. We do not believe that radiant light and heat will help very much in the cure of chronic, purulent otitis media, at least our experience has led us to employ this form of energy only in the acute type of middle-ear infections. In the chronic discharging ear, ultraviolet light has earned for itself a definite place in therapy.

One must first ascertain the presence of bone infection, *i.e.*, sequestra or caries or marked mastoid involvement, and for this purpose the X-ray aids in the diagnosis. Ultraviolet rays will not replace surgery, and when a chronic otitis has reached a point of surgical indication, operative therapy is, of course, the measure to be

Fig. 47.—Cleansing of ear canal by suction.

adopted. There are, however, many patients who suffer from chronic running ears, in whom no definite surgical indication is present, and for this class quartz-light energy offers prospects of curative results.

Recent investigations have taught that in conjunction with ultraviolet rays in middle-ear infections certain fluorescent substances are advantageously employed. These compounds seem to augment the treatment with

light rays. Eosin solution was first suggested and, in many instances, served the purpose. Since the newer anilin dyes have come into common use, mercurochrome is now to be preferred. Its action as a fluorescent substance is similar to that of eosin. In darkness, these fluorescent substances are not as toxic as in the presence of sunlight or of the light from a carbon

Fig. 48.—Instillation of mercurochrome solution.

arc or mercury vapor quartz lamp, for it has been fairly well established that, in the presence of light, concentrated from either of these sources, these fluorescent substances acquire the power of destroying infusoria and of neutralizing toxins and enzymes. Formerly, fluorescent substances were injected. This method may be helpful if a systemic reaction is desired.

In otorrhea the irrigation method is obsolete. Instillation of a two to five per cent mercurochrome solution into the ear canal, after first cleaning the canal by suction (Fig. 47) and dry swabs, is satisfactory. The solution is permitted to remain in the canal from five to fifteen minutes (Fig. 48), after which the excess is wiped out. The ear is now ready to be irradiated with the

Fig. 49.—Irradiating ear with ultraviolet light from a water-cooled lamp. Note quartz applicator fitting into canal.

water-cooled quartz lamp (Fig. 49) through suitable quartz rod applicators. This can be accomplished under direct vision. The first treatment should not exceed one minute, each subsequent treatment being increased by one-half minute. The voltage of the lamp always should be accurately measured.

In the beginning of our work, the tendency was to minimize the duration of treatment. Added experience

has taught us that heroic doses are frequently necessary. We have cautiously given as much as ten minutes at one sitting after the patient's tolerance had been raised and shorter time treatments had failed, and have obtained more favorable results. Such dosage, however, is not generally advocated, but the ability to judge the proper duration comes after some experience. It should, furthermore, be emphasized that the blistering effects of the quartz burner must be known, its total hours' use influencing the effect produced. By the condition of the burner one can actually gage the duration of the treatments, because it is well known that a new burner gives the desired reaction much more expeditiously than one that has seen much use.

A few reports will prove illustrative:

W. C. B., female, aged 18: chronic running ear of 9 years' duration, following measles. Various treatments had been given from time to time, with some cessation of discharge, but there always were remissions. The ear was treated by the method above described, with suction, mercurochrome and ultraviolet light, and after twelve irradiations the discharge stopped. One year has now elapsed and there has been no recurrence. General ultraviolet irradiations with the air-cooled lamp supplemented the local treatments.

H. S., woman, age 33, married: discharging ear since early childhood, following scarlet fever. Was in the habit of using boric irrigations daily. We prescribed 2 percent mercurochrome, for home use, and dry-cotton swabbing, and the treatment, as above outlined, three times weekly at office. This patient did not respond as promptly as the others, and it was not until the treatment periods reached ten minutes that the discharge finally ceased. The entire course lasted nearly three months, resulting in a cure, with no recurrence after sixteen months.

Local and General Therapy in Chronic Purulent

Otitis Media.—Ultraviolet energy for otitis media does not conflict with other local measures which may be indicated. Obviously, adequate attention to nasal and pharyngeal pathology is of the utmost importance. If inflations of the eustachian tubes are indicated, these should precede the lamp irradiations. Little or no home treatment is advocated, but when found to be necessary for good reasons, a 2 per cent solution of mercurochrome is to be dropped into the ear canal once daily. At no time are irrigations with other medicated solutions to be employed. Dry cotton swabbing, if frequently carried out, will help to keep the ear canal reasonably clean and free from accumulations.

If a culture and smear are taken prior to the first treatment, occasional checks can be made to determine progress. To this must be added the X-ray as a valuable diagnostic aid. It must be admitted that the results are not always ideal. Some patients frequently present, at a later time, an underlying focus which was at first obscure, or else the general physical condition was such as to indicate proper systemic therapy. General ultraviolet exposures with the air-cooled lamp are always of pronounced value in these individuals, that is to say, supplementing the local applications with the water-cooled apparatus. One should not overlook the fact that success depends, in a large measure, on the accuracy of diagnosis, for without the proper selection of cases, ultraviolet or any other form of therapy will fail to produce the desired results.

Zinc Ionization in the Treatment of Chronic Suppurative Otitis Media.—Our knowledge of the benefit of zinc ionization in local sepsis is based on the original investigations of Professor Leduc of Nantes. Experience has

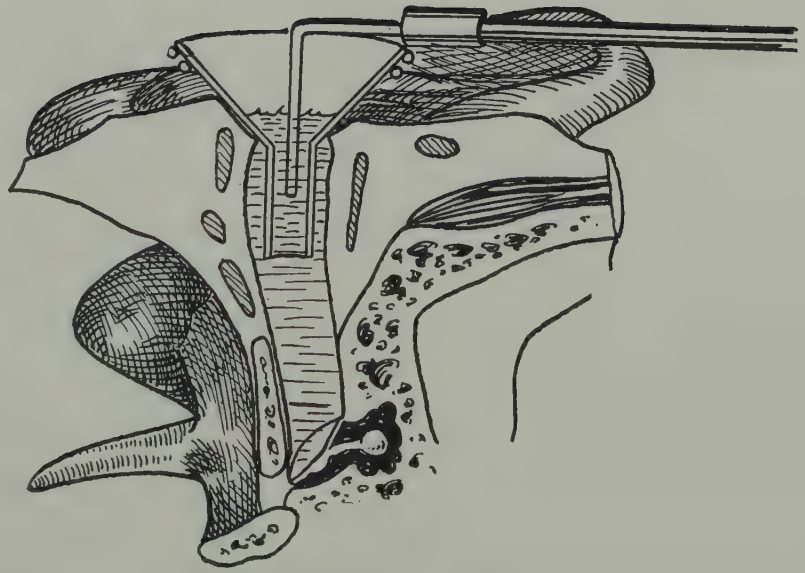

Fig. 50.—Diagramatic sketch of ioniztaion of ear.

confirmed the views of Friel, who holds that zinc ions coagulate albumen and the electric current makes the ions penetrate to any depth required. "The coagulation of the albumen of cells, whether they are tissue cells or bacteria, involves their death. Thus the exudation is sterilized. The solution of the zinc salt can be used so weak that it does not irritate. The electric current takes the ions from a weak solution and deposits them homogeneously in the exudation as readily as from a strong solution.

"The coagulum that is formed is moreover a sterile barrier between the tissues and the exterior. Rest is afforded to the tissues, which rapidly progress toward structural integrity and functional efficiency." (Friel.)

Friel contends that the possibility of applying zinc ionization successfully in the treatment of the individual case of chronic otorrhea depends on:

1. The situation of the septic material.
2. The presence or absence of factors additional to infection of the discharge, which favor the continuance of the otorrhea.

In tabular form:

1. Tympanic conditions. *a*. Tympanic sepsis alone, or with granulations, polypi or caries.
2. Tympanic conditions plus eustachian obstructions or infection from septic tonsils, inflamed adenoids, rhinitis, sinusitis, septic teeth.
3. Tympanic conditions, plus inflammation of the external auditory meatus.
4. Tympanic conditions plus mastoid or attic disease.

Tuberculous disease of the middle ear should not be treated by ionization, because the tubercle bacillus is in the tissues as well as in the discharge. Other contraindications to ionization are: (1) the presence of granu-

lations or polypi; (2) an area of caries in the tympanum; (3) mastoid or attic involvement; (4) the existence of reinfecting foci, such as purulent rhinitis, inflamed tonsils and adenoids and nasal sinusitis.

According to Warwick, in cases of tympanic sepsis pure and simple, treatment by ionization alone is sufficient, especially so, if the perforation in the drum membrane is large enough to allow the introduction of the zinc solution and its distribution in sufficient amounts.

The technic is as follows:

1. Cleanse the ear thoroughly and irrigate with a weak zinc sulphate solution.
2. Have the patient lying with the infected ear up (Fig. 50) and fill the ear canal with zinc solution (one grain zinc sulphate to one ounce of water).
3. With a direct current apparatus, connect a zinc wire to the positive pole and pass the other end of the wire into the ear canal protected by a special rubber speculum. (Fig. 51).
4. The negative pole may be a moist sponge electrode held in the hand of the patient, or a piece of lead foil placed on the patient's back or any other suitable place on the body.
5. From two to four milliamperes of current are allowed to pass from ten to fifteen minutes.

Complete cessation of discharge has taken place after one treatment, and after a few days the ear becomes dry and free from inflammation. Warwick believes that if there is a failure in what seemed to be a suitable case for ionization, and the discharge continues after the first treatment, it is probably due to the hole in the ear drum being too small to permit the zinc solution to enter. At the next treatment the solution should be injected through the hole with a small syringe, the procedure then being carried out as described.

Jobson treated 45 suppurating ears by ionization, and in 29 the otorrhea ceased rapidly, two relapsed after a few weeks, thirteen were not cured, and in three cases the result is not known. This gives sixty per cent of cures. Of the patients not cured, six had choleste-

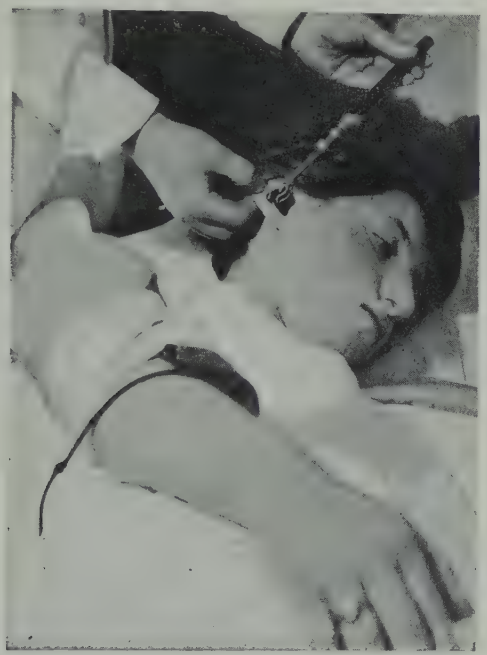

Fig. 51.—Zinc ionization showing actual operation. The indifferent electrode is on the patient's right arm.

atoma and two were old cases that had been operated for mastoiditis. Twenty-two of the successful cases required only one ionization; four required two treatments; two received three treatments, and only one as many as four. If the discharge does not dry up after

two or three ionizations, it is not likely to yield to this form of treatment. One ear which had been discharging for 27 years dried up with one treatment. The author concludes that the advantages of treatment by ionization are: (1) that it will cure any case of otorrhea which is curable by drops; (2) that it will accomplish this in infinitely less time, and (3) that it will cure a large number of cases which do not improve under ordinary antiseptic treatment.

Our own experience with zinc ionization in chronic otitis media has been good. The importance of proper selection of cases cannot be too strongly stressed. Otologists who condemn the procedure because of poor success, will usually find that there was some contraindication for the method. It is prudent to control the diagnosis with the X-ray. for many times a chronic otorrhea is found to be due to mastoid involvement. Such a case naturally lends itself only to surgical intervention.

Finally, zinc ionization is a procedure presupposing thorough familiarity with ear pathology.

Chronic Non-Suppurative Otitis Media; Nerve Deafness and Otosclerosis.—(See Chapter on Defective Hearing.)

CHAPTER XII

THE MASTOID AND LABYRINTH

Radiant Heat-Light in Mastoiditis.—Reference already has been made to the use of the high-powered incandescent lamp in otitis media. In several instances we employed light treatment in mastoiditis with equally good results when operation was refused and when the severity of the symptoms indicated that some measure had to be employed to afford the patient some relief. Oeken applied light in five cases of mastoiditis with success. Woodbury, in a series of cases, likewise obtained good results.

Woodbury believes that radiant energy is effective by conversion into long obscure heat waves, which are absorbed and carried by continguity of structure and conversion through the blood. This heat, he contends, has a local effect upon cellular metabolism of the cells themselves by reason of the heating of the cellular contents and the increased supply of invigorating blood. The increased blood supply is due to the well-known vasomotor response to heat.

We employ incandescent lamps of one thousand watts. In the home, when a high-powered bulb is not obtainable, an apparatus can be improvised by the use of a heavy pasteboard shade and an ordinary house light bulb, but such an arrangement should be replaced by a high-powered lamp as soon as possible.

Acute mastoiditis if uncomplicated responds to the energy from an incandescent lamp. If, however, no improvement is noticeable within five or six days, it may be assumed that some complications exist. In such event surgery must, of course, be resorted to. Early treatment is essential if operation is to be averted. Radiant heat-light may ameliorate the symptoms if applied late, but will prove valueless so far as preventing surgical interference.

The Labyrinth.—The galvanic current has been serviceable in establishing the diagnosis of labyrinthine disease. Coleman, referring to the galvanic test, although it had been used for a long time, wrote: "In the rotation and caloric tests, nystagmus results from stimulation or inhibition of one of the centers by change of position of the ampullary cilia. In the galvanic tests mystagmus results from altered electrical tension of one or other of the centers by conduction along the vestibular nerve. If one electrode be held in the hand and the other applied in front of the tragus, nystagmus and vertigo will be produced."

The method in vogue for testing the labyrinth was described by Coleman thus:

"Living tissue, muscle, nerve center, etc., is in a state of catelectrotonus, that is, of increased excitability to an electric current at the cathode. In making the tests, the ordinary wall cabinet with milliampere meter and pole switch is employed. One electrode is held in the hand and the other is applied in front of the tragus.

"The examiner must throw the light from his head mirror on the eye, raise the upper lid and be on the watch for the first signs of nystagmus. The current is turned on and gradually increased till nystagmus appears.

The reading of the meter is noted as well as the direction of the nystagmus. Whichever pole is applied in front of the tragus, the nystagmus will always be to the cathode.

"Before the current is turned on, both centers are equally balanced in a state of catelectrotonus. The cathode is now applied to the right ear. There follows a series of slow movements to the left, with rotary nystagmus to the right, or nystagmus to the cathode.

"On the application of the anode to the right ear, the electrotonus of the right center is diminished. The slow movement, therefore, is to the right and the nystagmus to the left—that is, it is as before, to the cathode.

"In normal cases, nystagmus will be brought about upon the application of the cathode by an equal amount of current on each side, and on the application of the anode, by an equal amount on each side.

"Six milliamperes is the average amount necessary to produce nystagmus when the cathode is applied, and eight or nine milliamperes the average amount when the anode is applied.

"In the early period of labyrinthine suppuration, galvanic reactions may be obtained even when the rotation and caloric reactions are negative. Later, however, degeneration of the vestibular nerve follows the destruction of its end organ, and when this has occurred, the galvanic reactions will not be elicited.

"With one labyrinth destroyed, the average milliamperage necessary to produce nystagmus is for the cathode, ten, and for the anode, four. With one labyrinth hyperesthetic, the average milliamperage is for the cathode one, and for the anode, eleven or twelve.

"The electrode which is applied in front of the

tragus should be fitted with a make and break mechanism."

Kubo has shown that in utilizing the electrodes of diathermy, which warm up the entire endolymph, it is possible to produce a vestibular nystagmus. The results of these experiments tend to explain the nature and value of this phenomenon. *Diathermic nystagmus* must not be confused with *galvanic nystagmus.* It is not observed when the diathermic electrode is applied to the mastoid process or over the tragus, as in galvanic nystagmus. It occurs only when a small diathermic electrode is applied in the depth of the external auditory canal. A small unipolar or bipolar electrode may be employed. The auricular electrode is fixed on the head by a metallic half circle similar to that used by telephone operators; it is covered by a pad of gauze moistened in saline solution, and is introduced into the auditory meatus. If a unipolar application is made, the second electrode is placed in the hand of the opposite side; but in a bipolar application each electrode is introduced into the auditory meatus. When the head is inclined 60° above the horizon—the best position for the horizontal semicircular canal—the nystagmus is very apparent. The direction of the rapid component is always to the excited side, as in the test with warm water. The nystagmus disappears on inclining the head 30° below the horizontal, but if the head is inclined still further, the nystagmus reappears, this time in an opposite direction. In short, the form and direction of the nystagmus depend on the position of the head.

This diathermic nystagmus was compared with caloric nystagmus in 15 pathologic cases. In acute otitis, caloric nystagmus appears slowly, as it is retarded by the hyperemia, pus, granulations, etc., while diathermic

nystagmus becomes evident as quickly as in the normal ear. The same results prevail in external otitis, polyps, and chronic otitis media. In perforations of the drum, or in chronic adhesive otitis media, caloric nystagmus appears very rapidly, while diathermic nystagmus appears normally. In other words, alterations of the external or middle ear that interfere with caloric nystagmus do not cause any modifications in diathermic nystagmus. The method may be used without danger for both qualitative and quantitative examination of the labyrinth in perforations of the tympanic membrane, in suppurative otitis media, and after aseptic operations in animals.

Fig. 52.—Functional testing of labyrinth with diathermy.

We have experimented in the testing of the labyrinth with a diathermy current which is used in connection with the special head band electrode. The sponge is first moistened and inserted into the ear through the hollowed attachment at the end of the rod which connects with the head band (Fig. 52). By increasing or decreasing the amount of current, and by means of a thermophile (Fig. 53) connected into the hollow sponge holder, the degree of temperature can be determined and an increase or decrease easily observed. When testing in this way a nystagmus is not difficult to detect, and is watched for

Fig. 53.—Thermophile.

in the same manner as when hot and cold ear douching is depended upon.

Electrical methods have not offered a favorable prognosis in labyrinthine disease. Coleman believed that in case of membranous involvement of the labyrinth—*per se*, or as a complication of middle ear catarrh—much could be expected from the application of electricity. The local application of static electricity is said to be of value, but this type of current is now used very little for this affection.

CHAPTER XIII

TINNITUS AURIUM

Tinnitus aurium is undoubtedly one of the most annoying symptoms encountered in otologic practice. It is so distressing and so unbearable at times that it causes the patient mental derangement. For these reasons specialists have made unusual efforts to solve the problem, resorting to a study of all possible etiologic and pathologic factors which may be at fault.

Tinnitus aurium implies the presence of subjective sounds in the ear, although we have come to recognize, also, an objective type of this symptom. Most physicians are familiar with the varying character of the sounds. The patient usually complains of some auditory sensation which he has heard frequently in his everyday life. Certain occupations sometimes predispose the make-up for its existence. This phase of the subject has been described so many times that details would be needlessly time-consuming.

More important would be a classification, because no treatment can be scientifically applied unless the etiology has, at least in part, been determined. We have searched the literature in order to find a satisfactory classification. Probably the best one is suggested by Kerrison in his textbook on "Diseases of the Ear." This author states that most cases of tinnitus aurium will be found to fall under one or other of the following heads:

1. *Obstruction sounds,* or noises due to occlusion or impaired mobility of some portion of the sound-conducting apparatus.
2. *Blood sounds,* or noises produced by the blood current in vessels in or near the ear, and due either to disturbances of the local or general circulation, or to abnormalities in the size, shape, or position of the vessels.
3. *Labyrinthine sounds,* or noises due either to structural changes in the cochlea, or to alterations—either increase or diminution—or intralabyrinthine pressure.
4. *Neurotic sounds,* or noises due to abnormal irritability of the auditory nerve.
5. *Cerebral sounds,* or noises due to abnormal conditions acting upon the auditory centers in the cerebral cortex.

Obviously, we cannot here discuss this classification. Suffice it to say that certain factors are well recognized. Tinnitus is a symptom which occurs in a large majority of cases of diseases of the ear, and in many systemic disorders with apparent lesion or suggestion of involvement of the hearing organ.

Tinnitus secondary to systemic ailments must be comprehensively considered at all times. Various phases of the subject are suggested by French, and we feel justified in quoting his very excellent account.

Tinnitus may occur in the following diseases of the ear:

1. Presence of cerumen, aural polypi or foreign body in external auditory meatus.
2. In any inflammatory disease, acute or chronic, suppurative or non-suppurative, of the middle ear. In catarrhal inflammation of the middle ear, the noise frequently has the character of bursting bubbles, and is due to movements of the viscid exudate in the ear itself. In otosclerosis, tinnitus is a very prominent and usually early symptom. It may occur before any alteration in hearing is present.

3. In diseases of the internal ear, tinnitus is especially liable to occur in a severe and intractable form. Thus, it is very likely to be present in Meniere's disease, syphilis of the internal ear, and in those lesions of the internal ear which may arise in the course of typhoid and other specific fevers, and also by extension of suppuration to labyrinth from middle ear.

Diseases in which tinnitus is a prominent symptom are: anemia, leukemia, pernicious anemia, aortic regurgitation, gout, nephritis, uremia, arterio-sclerosis, migraine; and in drug, tobacco and ether or chloroform intoxications; and in persons who use the telephone constantly, —*telephone ear.*

Blood Pressure and Tinnitus.—Recent studies have attracted attention to hypertension as an important factor in tinnitus aurium. Doubtless in numerous instances, either a hypertension or a hypotension may be at fault, contrary to the older belief that high blood pressure only is of etiologic significance. Wharry considered the various angles pertaining to tinnitus aurium associated with abnormalities of blood pressure and emphasized (1) that tinnitus may be due to high blood pressure alone, or to low blood pressure alone, in which case it is usually found to be bilateral; (2) that it may be due to an aural lesion combined with high blood pressure, or with low blood pressure, in which case the tinnitus is on the side of the lesion; (3) that in the circumstances just quoted, the tinnitus may be cured or improved by removing the aural lesion alone, or by reducing the blood pressure to approximately normal, or by doing both.

Our experience in tinnitus cases associated with abnormalities in blood pressure has been that often the blood pressure factor is satisfactorily attended to by the internist—with no relief of the auditory sensations. In other

words, the tinnitus very frequently persists after the assumed primary cause is removed. It is for this class of cases, in particular, that we advocate the application of physical therapy. This will be discussed in detail under treatment.

Endocrines and Tinnitus Aurium.—Among the newer theories advanced regarding the causation of tinnitus is one which involves the ductless glands. We are cognizant of the value of organotherapy in tinnitus aurium, especially the type associated with impaired hearing. However, we have not had sufficient experience with this treatment to pass an opinion. The report of Seal, a few years ago, spoke favorably of the influence of thyroid and adrenal substance upon the condition when it resulted from gland exhaustion, or was due to a deficient activity of the adreno-thyroid apparatus. Seal wrote: "The extract of a gland organ will exert an exciting influence in the same organ, so that a sluggish gland can be prodded into activity to a degree quite beyond belief and result in a glandular readjustment. The thyroid gland is undoubtedly largely responsible for the distressing symptom of tinnitus aurium." Seal attempted to explain this on the basis of a thyroid deficiency causing a generalized infiltration in which cellular growth and oxidation is interfered with throughout the body. When this infiltration affects the auditory apparatus, we get the characteristic symptoms of tinnitus aurium without any definite ear lesions.

Objective Tinnitus.—Before passing to the treatment of subjective tinnitus, mention should be made of the objective type. The literature is scant, and although objective tinnitus is rare, the physician should always be on the alert when a case of tinnitus is examined.

McAuliffe, in 1908, gave an interesting account of a case of objective tinnitus due to convulsive tic of the tensor and levator palati. The tinnitus was quite audible. In 1915, Mollison published a report of an audible tinnitus in a boy. The tinnitus stopped when the carotid was compressed, and upon cessation of pressure the sound returned. This led Mollison to believe that a vascular condition was the underlying cause of the noise.

Treatment.—In treating tinnitus aurium every effort should be made to remove the underlying pathology in the nose, throat and ear, and to exclude any obvious systemic cause. Thus, if tonsils and adenoids interfere, or if a deviated septum or turbinate bodies suggest etiologic relationship, these are properly attended to by medical or surgical measures.

On the other hand, if an intoxication is the basic factor responsible, either from tobacco or drugs, prompt discontinuance of either is advised. In some instances, however, the intoxication may be due to gall bladder infection, to appendicitis, or obscure infections, and when adequate treatment is instituted, relief is usually obtained.

Again, numerous patients have tinnitus associated with a deafness of catarrhal etiology of long standing, and in spite of the fact that the pathology is removed or corrected, the tinnitus persists.

The usual treatment such as inflations, drug therapy, diet and thorough elimination should always be given a trial. While a cure is possible only occasionally, relief can be afforded in a large percentage of cases.

When the routine measures fail or appear to be inadequate, heat should be applied to the auditory mechanism. The principle is to pass heat of a sufficient tolerance

through the eustachian tubes. This may be done by several methods. The indirect method consists in having the operator attach diathermy electrodes to his hands and then introduce the index fingers in the patient's ears. Or the patient may hold the palm electrodes in his hands and introduce the index fingers in his ears. Still another plan is to place wet cotton plugs into the ear canals and insert electrodes into the wet cotton. When it is desired to treat one ear, an indifferent electrode may be placed on the back of the patient's neck or in his hand.

An improved method is one which involves the use of a special headband and electrodes as suggested in the treatment of defective hearing (See Chapter XIV).

We recommend also diathermy intranasally, as far back as it can be applied, at each sitting. This is done with the unipolar Oudin or Tesla current for twenty minutes. The diathermy in the ears must be applied for at least twenty minutes. Intranasal diathermy is followed by ultraviolet irradiations. The following case reports are submitted as illustrative of the types of patients treated, the character and extent of former therapy, and the nature of the therapy employed with special reference to diathermy.

R. L., age 45, male, druggist, suffered from tinnitus for twelve years. He attributed his trouble to a pneumonia, as he had never noticed the symptoms before this illness. Inflations, operative procedures on the nose and throat, and X-rays, produced no relief. Thyroid extract, as well as other medication on a systematic basis, proved of no benefit. He always noticed that local heat in some form was palliative. There was no definite impairment of hearing. Diathermy was applied to both ears, one ear being treated at a time, for a period of four weeks, four treatments weekly. At the end of this course, the tinnitus was almost negligible, but returned

later when no treatments had been taken for about two months. The diathermy was resumed, and after a few applications, relief was again obtained. In this case, it is especially interesting to note that of all the measures utilized, diathermy was the only one which gave some promise of being beneficial.

W. C. B., 39, female, tinnitus aurium six years. Internist's examination negative. Blood pressure within normal limits. Claims to have had no trouble prior to childbirth. Usual remedies of no avail. This patient received sixteen treatments in four weeks, and at the end of this time she was completely free from the distressing symptom. A recurrence was recognized by her two months later and the diathermy treatments were resumed. This time the aural diathermy was supplemented by ultraviolet body radiations. The improvement since has been more marked, but this patient is still under observation and treatment.

No claim can be made that diathermy is a specific for tinnitus aurium, nor that it will cure any case; we contend only that it is a valuable aid in its management. It will relieve many patients, the relief being of longer duration in some instances than in others. Diathermy alone without supplementary measures to meet such constitutional indications as may exist, is without value.

CHAPTER XIV

DEFECTIVE HEARING

General Remarks.—Since the advent of modern electrical agents in the field of therapy, a solution of the defective hearing problem has been approached with an added impetus. During the past few years much work has been done with X-rays on the hard of hearing, but otologists are not yet agreed regarding the value of this agent. Our own investigations were made on the use of diathermy, the sinusoidal current, galvanism and ultraviolet radiations, singly or in combinations, in all types of acquired partial deafness. We do not feel that the time is ripe finally to report on our observations with X-ray therapy, although some concrete facts can be adduced from our work. We quote from the contributions of authors who have employed X-rays to a larger extent than we have done. The reader is referred to the appendix for some interesting experimental data on diathermy in hearing cases.

Clinical Studies.—The cases selected for treatment were principally those of chronic catarrhal otitis media, usually with complete or partial fixation of the stapes, while some cases were clinically very much like otosclerosis and partial nerve deafness. Many of the patients had been previously treated by numerous methods, and some had operative work done on the nose and pharynx. Psychological reactions were recognized where possible, and these conditions were discounted. The following are our conclusions: (1) Negative galvanism is of slight ben-

efit in a few cases. (2) The sinusoidal current in itself has little or no value. (3) Diathermy applied by the methods advocated heretofore (*i.e.*, via the external auditory canals) is of doubtful benefit. (4) Local ultraviolet radiations to the ears have no therapeutic effect so far as hearing is concerned. (5) The quartz ray applied for its systemic effect may alter general metabolism and indirectly act as an influencing factor.

New Diathermy Technic.—The technic which we now employ is based on the results of our laboratory studies. The electrodes of the special apparatus are so applied that the heat is not directed through the ear canals but instead, the active electrode is placed in contact with the mastoid (Fig 54) area of the ear to be treated, while the indifferent electrode is placed on the opposite side (Fig. 55) anterior to the ear. Thus, only one ear is treated at a time. By this technic the point of greatest heat is at the desired area, namely, the petrous portion of the temporal bone. Three to four treatments weekly are given, with a milliamperage of 300-400. Each diathermy treatment lasts thirty minutes and is followed by negative galvanism for five minutes. The actual number of treatments necessarily varies and can be determined only by the requirements of each individual case.

Fig. 54.—Active electrode over mastoid area.

Fig. 55.—Position of indifferent electrode.

Improvement should be apparent to the physician during the third week of treatment. The hearing should be tested at least once a week.

TABLE—Results of Tests on Human Subjects.

	Patient	Age	Date of First Examination	Tuning fork Tests of Ear Treated				Whispered Voice	Nasopharyngeal Pathology
				High	Low	Rinne	Weber		
1	R.B...	23	12/22/24	1,024	64	Pos.	O	R2′	O
2	T.G...	43	4/15/25	2,048	256	Neg.	R	R2′	+
3	M.S...	45	11/8/24	1,024	512	Neg.	L	L6′	+
4	O.P...	45	12/12/24	2,048	128	Neg.	R	R0′	+
5	T.O'B.	27	4/21/25	2,048	64	Pos.	O	Cont	O
6	R.R...	28	2/7/25	1,024	64	Pos.	O	R4′	++
7	A.M..	23	7/8/24	2,048	128	Neg.	L	R2′	+
8	V.B...	30	6/25/25	2,048	256	Neg.	O	R2′	+
9	S.C...	37	4/11/25	2,048	512	Neg.	L	R2′	+
10	N.La..	35	7/11/25	1,024	64	Pos.	O	Cont	+
11	F.Lu..	30	6/23/25	2,048	256	Neg.	O	R3′	++
12	D.W..	27	9/13/24	2,048	512	Neg.	O	R2′	+
13	L.Z...	18	12/13/24	1,024	512	Neg.	R	R1′	++
14	E.B...	32	8/24/24	2,048	64	Pos.	O	L6′	+

In our cases (Table) progress has been noted in subjective terms and in whispered voice tests. In performing the latter, we always had reasonably uniform conditions, a very quiet hallway with distances marked off on the wall, loud forced whispered voice after expiration, and all tests by the same individual without knowledge of previous records. We realize that these tests give inaccurate figures, and therefore are of but relative value in recording the progress made by the treatment.

To overcome some of the inaccuracies of testing, we recently installed an audiometer (Fig. 56) by means of which we are able to chart precise records of qualitative and quantitative changes obtained by various forms of treatment.

TABLE—*Continued.*

Tinnitus	Duration of Impaired Hearing	Previous Treatment	Familial History	Whispered Voice in Ear Treated			Results	
				After 6 Treatments	After 12 Treatments	After 24 Treatments		
O	2 yr.	No	+	R6′	R6′	R7′	No improvement	1
+	12 yr.	Yes	+	R5′	R15′	R27′	Improved	2
O	10 yr.	Yes	++	L10′	L6′	L35′	Improved	3
O	15 yr.	Yes	+	R10′ L.W.V	R20′ W.V.	R30′	Improved	4
O	20 yr.	Yes	O	18″	24″	....	Slight improvem't	5
O	8 yr.	Yes	O	R10′	10′	10′	Slight improvem't	6
O	7 yr.	Yes	O	R6′	R15′	R20′	Improved	7
O	10 yr.	Yes	O	R12′	R20′	R27′	Improved	8
Occ.	15 yr.	Yes	No	Same	R3′	R10′	Slight improvem't	9
O	10 yr.	Yes	+	R0′	R0′	R0′	No improvement	10
O	2 yr.	Yes	O	R10′	R12′	R18′	Improved	11
+	3 yr.	Yes	+	R6′	R12′	R25′	Improved	12
O	15 yr.	Yes	O	R6′	R10′	R25′	Improved	13
O	5 yr.	Yes	O	L10′	L25′	L25′	Improved	14

Types of Deafness.—The three types of partial deafness commonly recognized are chronic catarrhal otitis media, otosclerosis and nerve deafness. In *chronic catarrhal otitis media,* according to Politzer, the pathological changes extend over the whole mucous membrane of the middle ear, or may be limited to circumscribed areas. "The structural changes in the mucous membrane consist of an increase in substance caused by round-cell infiltration, or in partial or total transformation of the new-formed round cells into fibrous connective tissue. The new-formed connective tissue may remain or lead to fixation of the ossicles by its contraction, calcification or ossification." (Politzer.)

What is the effect of diathermy on such pathology?

In general, it may be said that diathermy produces localized heat in deep tissue, the penetration and degree of which are always under control. In treating an ear in which there are structural changes in the mucous membrane to the point of fibrous connective tissue formation, or fixation of the ossicles, the purpose of applying diathermy is similar to that of treating a joint. Absorption of calcified deposits may be effected to such a degree that function is at least partially restored. Diathermy increases the arterial flow in the part treated and augments the return circulation. Intercellular tension is thus altered and cellular activity stimulated. Furthermore, it is fairly well accepted that sedative diathermy aids in the absorption of effusions, the softening of exudates and fibrous tissues, and in the relaxation of muscle spasms.

Politzer believes that in *otosclerosis* there is primarily disease of the bony labyrinthine capsule. The pathological changes in the labyrinth as noted by him are: osseous new formations, atrophy of Corti's organ, atrophy of the acoustic nerve in the cochlea and of the ganglionic layer in the spiral ganglion, and atrophy of the origin of the acoustic nerve.

Syphilis, gout, uric acid disease and other conditions have variously been associated with otosclerosis. Attention has been directed to the relationship of the blood calcium to this type of impaired hearing. The contention of Kobrak, Leicher and others that a deficiency in the calcium retention of the body is an etiologic factor, has been considered by many investigators.

Kopetsky and Almour support the contention that otosclerosis is probably associated with a calcium deficiency. Some writers, however, are inclined to believe that the

more important etiologic factor is the vitamin deficiency of the fat soluble A.

On the basis of accepted local pathological findings, and recent investigations concerning the constitutional factors involved, it is quite obvious that more than local treatment is necessary to influence the impaired hearing in otosclerosis. Treatment must be directed toward a correction of the constitutional error. Ultraviolet radiation is of value for this purpose, since this agent influences the calcium retention in the body.

Treatment directed toward correction of any vitamin deficiency also influences selected cases. While diathermy locally, and ultraviolet radiation generally, have been helpful to many patients, it is not intended to convey the idea that these measures can be depended upon to the exclusion of others.

Reference has already been made to some of the *nerve changes* that occur secondary to otosclerosis. All nerve disorders ranging from the simplest form of neuritis to complete degeneration of the nerve are known to occur. Such changes may take place without obvious reason or may be secondary to affections in the ear, nose or other parts of the head. They may exist as complications or sequelæ of a multitude of systemic diseases.

It is quite obvious, therefore, that indications for treatment are manifold and varied, and that the prognosis is in direct proportion to the extent of the pathology.

The beneficial effect of diathermy on such nerves is problematical. Theoretically, its sedative action synergized with negative galvanism is indicated. Clinically with us, however, the application of these two agents has been purely empirical.

Comment.—Animal and clinical studies lead us to believe that diathermy is the physical agent of choice in the treatment of progressive undifferentiated defective hearing. No claim is made that this form of therapy is specific, nor that it replaces other orthodox measures which may offer a favorable prognosis, but experience in a fairly large series of cases has demonstrated its value after other accepted measures had failed. The improvement obtained depends upon four important factors: (1) Nature and extent of pathology. (2) Correct apparatus and electrodes. (3) Proper application based on anatomic principles. (4) Persistent treatment over a long period of time.

The permanency of the improvement and to what extent a curative state can be approached can be determined only after further lapse of time. For the present, however, from the results thus far obtained, we feel justified in continuing this experimental work and have reported our findings in the hope that others will become interested in this difficult problem.

X-rays in Deafness.—Work in this field which stands out very prominently is that of Richardson of Washington and Stokes of New York City. Stokes, in discussing the subject, writes: "It is well known that the endocrines are the regulators of metabolism and it must be conceded that disturbances in the endocrines are likely to lead to various types of pathology in so-called end organs, such as, for example, the ear, through disorders in metabolic activities. If these disorders in the endocrines follow infectious disease, local infections or various other stresses, then we may look for disturbances in their projected metabolic fields."

According to Stokes, endocrine dysfunctions are basi-

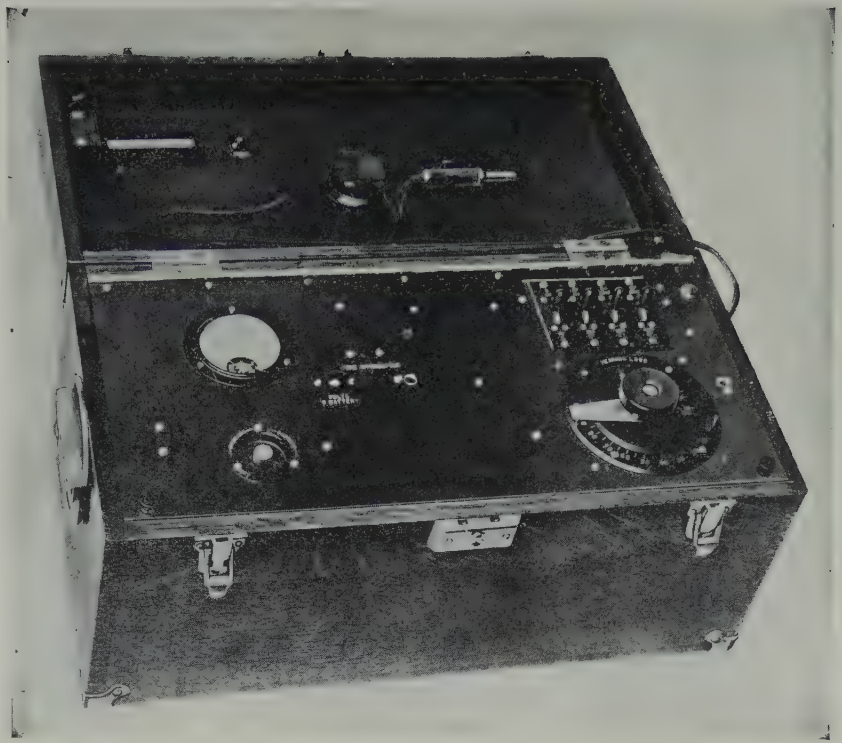

FIG. 56.—Audiometer.

cally at fault in impaired hearing, especially in otosclerosis, and this is his chief reason for X-ray therapy. He advocates so-called "diminutive" doses, directed toward the endocrine field involved and reports gratifying results in many cases of deafness heretofore classed as hopeless.

We are in accord with this author, that these diminutive doses are harmless. We do not agree with him, however, that the X-ray used in conjunction with diathermy is of any value. Our investigations have definitely proven that the hearing of patients who had improved with

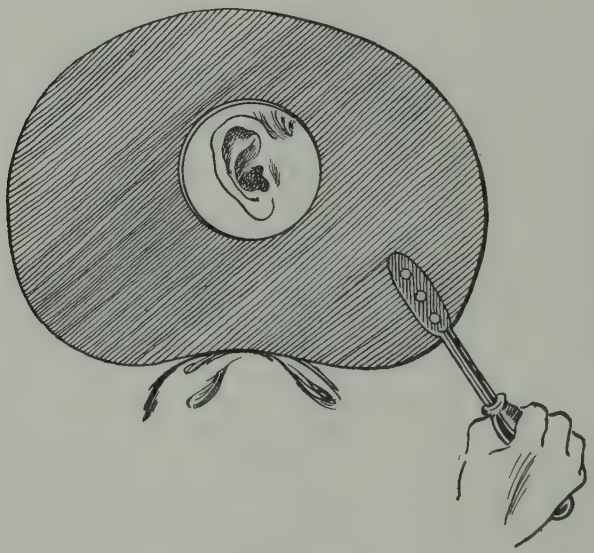

Fig. 57.—Position of lead protective shield for X-ray treatment of ear.

diathermy alone is made worse when X-ray therapy is added. This does not mean that X-ray therapy alone is not of value, but that when combined with diathermy the results are poor.

Stokes' method of giving X-rays is to cross fire from four directions (Figs. 57 and 58), thus reaching not only the pituitary (Fig. 59), but the pineal, thyroid, parathyroids and thymus as well. "It is obvious that the early improvement in hearing cannot be due to changes in the conductive apparatus; it must be due to sensitization of the perceptive field through changes in the semi-permeable membranes in the synapses, or end organs, or both. What part the radiated and stabilized endocrines through their hormones play, remains to be seen." (Stokes.)

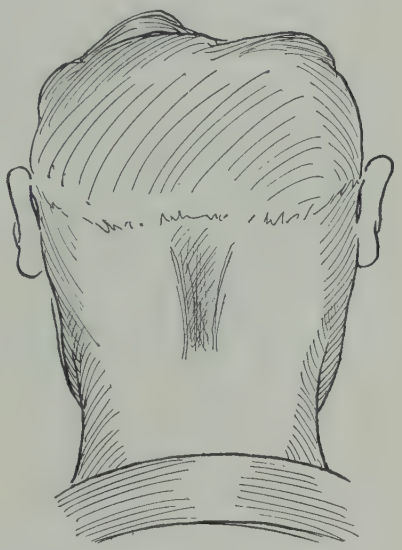

Fig. 58.—Position of head for posterior exposure.

Richardson first classifies cases of deafness into three categories:

1. Deafness originating from invasion of the structures with the products of inflammatory pathology.
2. Nerve deafness.
3. Deafness consequent to an invasion of the structure with calcific and sclerotic material leading to the condition generally known as otosclerosis.

Richardson believes that in the first category the inflammatory changes involve particularly the lymphadenoid structures; and since X-rays are definitely active in the dissolution of lymphadenoid material, it appeared

to him proper to employ a sclerolytic X-ray dose which has for its factors the following values:

Milliamperes	5
Kilovolts	8 (Root Means Square)
Tube skin distance.....	15 inches
Filter, aluminum	1 millimeter
Time	4½ minutes

The technic is given by same author as follows:

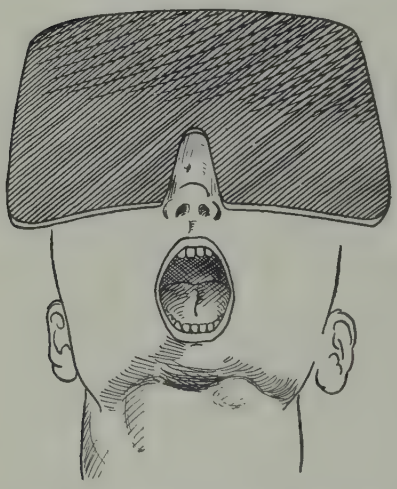

Fig. 59.—Anterior exposure with head tipped backward and mouth open; eyes protected by lead plate.

The patient rests upon the X-ray table ventrally, the head inclined to the right. Adequate leaded leather protection is placed over the patient so as to cover all but the head. Over the head a square of lead foil is placed which carries an ovoid opening about one-half by three-quarter inches in its diameters. The opening is placed over the external meatus, which is thus exposed. Following the exposure just mentioned, the head is turned to the left and the other ear is similarly treated.

The hearing does not improve immediately, but gains as the hyperplastic tissues reduce. This becomes apparent in six to ten days. An interesting point made is that while some types of catarrhal deafness have recovered, no improvement was noted in cases of nerve deafness

when the range between b′ and g″ is impaired. Tinnitus and vertigo, which so often accompany this condition, are quite frequently relieved. On the other hand when the range b′ and g″ is still present, the hearing impairment is stopped from advancing and quite often the acuity of hearing is perceptibly increased.

In some cases of nerve deafness Richardson has employed an extremely small fraction of the sclerolytic X-ray dose with gain in hearing that was strikingly impressive. Good results were obtained also in functional deafness and all forms of deafness that are benefited by whatever treatment improve more promptly and more substantially when the treatment includes also neural stimulating X-ray doses.

In a series of 850 cases, improvement varying from a slight degree to a complete cure, was noted in not less than 60 per cent of those treated.

Richardson's studies attracted much attention and led other otologists to pursue a similar therapy. Kahn, Warwick and others published reports which suggested encouraging results. Richardson does not speak of the added use of other physical agents, and in this particular, his work differs from that of Stokes.

We are at present carrying on experiments in hearing cases with X-ray therapy, independent of, and in combination with other electro-physical measures, but we have not yet sufficient data for a final report. In nerve deafness and in otosclerosis, recent investigations in blood chemistry and in the metabolic and endocrine aspects of these affections, tend to direct our attention to the value of adequate therapy for such associated dyscrasias as appear to be present. These facts we have already emphasized.

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PART FOUR

TREATMENT OF DISEASES OF THE NOSE AND ACCESSORY SINUSES

CHAPTER XV

AFFECTIONS OF THE SKIN

Dermatoses.—There are various types of skin affections which involve the nose. Some are due to local and others to systemic causes. Acne pustulosa, acne rosacea, furunculosis, eczema—these and many others, are frequently called to the attention of the rhinologist, although they are more appropriate for the dermatologist. When the cause of an acne or an eczema is definitely attributed to some local factors, a good prognosis is assured. Ultraviolet light is the remedy *par excellence* and should be employed as frequently as it appears necessary. Irradiations with the water-cooled lamp are best given at an established distance of six or twelve inches. The time of application is gaged on the distance adopted and the blistering effect of the burner. This latter fact should always be known by the technician or operator before commencing treatment. If a six inch distance is used, the first treatment should consume not over one-half minute, increasing by one-half minute at each sitting. If on the other hand, a twelve inch distance seems more desirable, then the time of the first application may be one minute. The increase at successive irradiations should not be varied.

After two to four treatments, an exfoliation of the epidermis, or a comparatively violent erythematous reaction will usually be observed. Neither of these should

be alarming. The patient is advised before commencing treatment of the likelihood of such reactions, for the skin affection disappears with them. It is a good rule to moderate the dosage, or in fact, discontinue the exposures altogether as soon as the anticipated reaction is obtained.

Acne rosacea yields to the use of the X-rays, although some specialists advise radium emanations. Quartz light from a water-cooled lamp has cleared up several of our cases without the use of other agents. If ultraviolet rays prove unsuccessful, X-rays, either alone, or in combination with the ultraviolet, should be employed.

A localized skin disease may be simply a local manifestation of some systemic disease. Local treatment is often of some value and may clear up the affection altogether, but recurrence is common until the systemic disorder has had attention. In eczematous conditions and in pustulous acne, diet, elimination and neurologic factors must be duly considered. For general alterative effect, body irradiations with the air-cooled lamp are not only valuable but hasten results.

Lupus Vulgaris.—While much work has been done in this country in treating lupus and other forms of tuberculosis of the skin, the pioneers were Finsen and Reyn of Copenhagen. Our technic and methods are based chiefly on their reports, the only difference being the fact that Reyn still maintains the superiority of the carbon arc over the mercury vapor quartz lamp. We quote from one of Reyn's recent reports: "In the treatment of lupus vulgaris, concentrated chemical light is absolutely indispensable, and it is of the greatest value to combine local treatment with light baths. The proportion of permanent cures thus obtained is about ninety per cent."

"The first light bath (with carbon arc lamp) is of 30-40

minutes' duration, followed by one every other day, increasing the time, so that after a fortnight, fully two and one-half hours are reached but seldom exceeded. If the patient is feverish or suffering from serious complications, such as tuberculosis of the lung, the author (Reyn) begins with baths of only fifteen to twenty minutes' duration, increasing the time slowly."

In using the quartz lamp instead of the carbon arc, as advocated by Reyn, it is quite evident that the duration of treatments is considerably lessened. The local effects on the nasal lesion itself is best secured by applying the rays from the water-cooled apparatus. Some suggest compression treatments, and no doubt good results can be had from this technic. We are in the habit of using a one or two inch distance, locally, supplementing this with general radiations to the entire body by means of the air-cooled quartz lamp every second day, or as the individual patient may require.

Robertson reported his results in treating a series of lupus cases with the quartz lamp, and of the series, two patients were cured, four partially cured or on the way to cure, and one patient was improved.

Ulceration and Infected Wound.—These yield readily to ultraviolet radiations. The principles of the treatment are similar to ulceration and infected wounds in the body. It is more or less established that the pathology of a chronic ulcer and an old infected wound is similar. Russ of Middlesex Hospital, London, wrote as follows: If a powerful source of ultraviolet radiation be directed upon an infected wound, the result of an adequate exposure will be that the pathogenic organism of the surface will be directly killed. Culture plates show that bacterial culture of small types, including the spores

of tetanus bacillus, upon radiation by ultraviolet light between 2,960 and 2,100 Angstrom units, were all promptly killed."

Schiller, who has done much work with actinic therapy in infection, commented: "There is no question in my mind but that of all agencies advanced in recent years to aid the body to restore an ulcerated or infected part to normal, the ultraviolet ray stands preëminent in ease of application, lack of pain, freedom from danger and in results obtained."

X-ray ulceration responds to ultraviolet rays. The credit for this discovery is due Sampson, who first suggested this therapy. The technic does not differ much from that used in the treatment of wounds. This subject is a very large one but beyond the scope of this volume.

CHAPTER XVI

THE NASAL MEMBRANES

Acute Coryza—Acute Nasopharyngitis.—Brooke has suggested a method of vibration with double prong vibratode over the interspace between the seventh cervical and first dorsal vertebræ, to produce a reflex impulse, the anatomic route of which was first called to his attention by Dr. A. P. Brubaker, "This reflex effect gives almost instant relief from the aggravating congestion and irritation and diminishes the profuse hydrorrhea with a definite subsidence of all coryzal symptoms. This application of the electrical vibrator, repeated several times during the first twenty-four hours, may alone suffice to absorb the so-called acute 'cold in the head'; more often, several days of such application are needed." (Brooke.)

Brooke states that additional treatment may be found necessary, especially if the acute affections have existed twenty-four hours or longer. If additional treatment is required, radiant light is an effective adjuvant, producing a deep hyperemia, which relieves the sense of fullness and congestion about the nasal mucosa and sinus openings, enhances local nutrition and gives the patient general relief.

We have found in electrotherapy an effective means to abort acute coryzas or to check them much more rapidly than can be accomplished by other measures, when treat-

ment is undertaken after the affection has existed for some time.

We have not used the method of vibration suggested by Brooke and are therefore in no position to pass on its merits. The use of radiant-light alone will frequently produce the desired effect. The acute symptoms subside promptly. If, as has been mentioned, the coryza has persisted too long for abortive measures to prove effective, the radiant-light treatment must be supplemented by the application of ultraviolet rays in the nose and by general body irradiations from the air-cooled lamp. We prefer not to use intranasal high frequency except when the measures suggested fail, in which case the intranasal ultraviolet is preceded by an application of the high frequency current with a non-vacuum electrode.

Where a tonsillitis, pharyngitis, or both, complicate the acute symptoms, attention to these foci is of prime importance. The ultraviolet ray, properly applied by means of a tonsillar or pharyngeal applicator, is quite effective in reducing the inflammation, particularly if general body irradiations with the air-cooled lamp are administered at the same time.

Supplementary general measures, such as purging, rest, regulation of diet are appropriate, and in no way conflict with the electrotherapeutic measures.

Acute Rhinitis.—In acute or subacute rhinitis, Thometz advocates galvanism. He uses as an indifferent electrode a pad soaked with bicarbonate of soda solution placed on the back of the patient's neck or beneath the palm of the hand. This electrode is connected with the negative pole. To the positive pole are attached two

pieces of copper wire of 18 or 20 gage thickness, coiled at one end to form a spiral contact around the terminal of a bifurcated cord. The straight portion is made about five inches in length, flattened so that it will hold the cotton with which it is now wrapped, dipped in a non-irritating germicide, such as a 5% protargol or 1-500 acriflavin, and inserted into the nose, successively in two directions, along the floor of the nose, extending into the nasopharynx; and upward and backward to include the region of the middle and superior turbinates. The average dosage is 7 milliamperes with 5 minutes duration of the electrodes in each direction. The treatment produces sedative and shrinking action while the deep germicidal effect of antiseptic positive ions cataphorically penetrate into the tissues.

There is no doubt that this method of treatment has many advantages. We have used it successfully a number of times after other measures had proven unsatisfactory. We are inclined to the belief that all so-called acute coryzas are complicated by sinus involvement. Our method embraces three definite steps, (1) radiant light; (2) argyrol tamponage, followed by intranasal ultraviolet radiation; (3) general body irradiations with the air-cooled lamp.

Radiant light therapy has already been described. We shall therefore proceed to discuss argyrol tamponage, known as the Dowling treatment. "Argyrol and other silver colloid solutions applied by means of tampons seem to precipitate the pus in the tissues, so that it may be extracted by the induced attraction and affinity of one colloid for another; for instance, pus is colloid and the silver solution is colloid."

"Nasal tampons of silver colloids also induce a watery precipitation from the mucous membrane, thereby practically depleting the tissue of watery elements and by the induced flooding the bacterial organisms are thereby weakened by repeated argyrol tampon treatments and the virility of successive colonies of organisms is surely overcome until there is no longer further propagation of the pathogenic organisms." (Dowling.)

Dowling believes that the silver preparations in colloidal form are in the best arrangement for deep absorption by the tissues. However, since diffusion of any colloid is a slow process, some method must be employed by which argyrol or other colloids may be kept in contact with the mucous lining of the nasal chambers for a prolonged period, thus providing a means through which argyrol or other colloids may be taken up by the vascular supply and carried to the distant organs.

It is not necessary to use a local anesthetic before instituting the treatment. "A single treatment is often sufficient for the cure of acute head colds, while for the more chronic conditions of the eye or sinuses, the treatment may be necessary over a period of months or even for several years." (Dowling.)

We believe we were the first to point out that intranasal ultraviolet radiation subsequent to argyrol tamponage greatly enhances the effects of the latter. Experimental work and many clinical observations properly controlled, have demonstrated the superiority of the combined procedure over either one alone, in some of the acute and chronic nasal infections. It is not unlikely that additional chemical changes take place in the mucous membrane or on its surface. Argyrol tamponage plus

intranasal ultraviolet radiation is the method of choice, in spite of the contentions by staunch advocates of each procedure that either method alone suffices.

Hyperesthetic Rhinitis—Nasal Hydrorrhea.—See the special chapter on this subject under "Borderline Diseases."

Atrophic Rhinitis—Ozena.—Galvanism in the form of zinc ionization has given good results in the hands of many rhinologists.

It is quite obvious that any active focus which may be present, such as a sinus infection, a chronic discharging antrum, dental pathology, etc., must first be eradicated. The practitioner must never forget the rôle played by tuberculosis, syphilis, and general metabolic disorders as underlying etiologic factors. If systemic causes exist, intranasal treatment unaided by the indicated therapy will, naturally, remain fruitless.

The odor is best controlled by tamponading the nares with cotton pledgets, saturated with a 2 per cent mercurochrome solution. These tampons are left in place for fifteen minutes, after which application of intranasal ultraviolet rays is given, beginning with one-half minute exposure for each nostril, and gradually increasing to ten to fifteen minutes, according to tolerance. It is astonishing how much quartz light the nasal membranes will tolerate as compared with the pharyngeal or tonsillar mucosa. In addition to the topical treatment general measures such as body irradiations, proper hygiene and diet, and the correction or removal of any apparent underlying etiologic factors, will in very many instances check this annoying affection in a comparatively short time. It is unscientific to assume that marked atrophy of bony

structures in patients who have had the disease untreated for years can be altered to any appreciable degree. In such progressed types we must be content with a symptomatic cure.

Leroux contributes an interesting report on the treatment of ozena by the high frequency current. His results of experiments with this agent have been so successful that he determined to attack the microbes *in vivo* by this method. The patients were carefully selected, none being regarded as ozenous unless there was marked atrophy of the turbinates with pronounced dryness of the pharynx and adherent crusts in the nasal fossae or nasopharynx. He used specially devised electrodes. Some were of the vacuum type and others were of malleable metal with ebonite insulation, adaptable to all irregularities of the nasal passages. Only the latter could reach the superior meatus which is so commonly the seat of ozena. Before application the mucosa was painted with formol ointment, which produced a hypersecretion, softening the crust and thereby preventing bleeding and reinfection.

The current was administered four to five minutes with the electrode placed horizontally in the nasal fossae; the electrode was then directed from below upward and the same amount of current given. An electrode was similarly used behind the soft palate. Since only the tip of the electrode is active, the patient can close his mouth and swallow normally during treatment. The wide nasal fossæ seemed at first to be most benefited by the treatment, while the regions not yet atrophic but still in the hypertrophic stage received no current. This was carefully remedied by painting their surfaces with 1:1000

adrenalin, after which the current was effective over a wider surface. Biterminal application seemed to offer no advantages over the monoterminal. Treatment was given daily. Crusts were eliminated, the ozenous surfaces shrank to thin pellicles without adhesions, and the mucosa gradually resumed its normal color.

The mode of action of the high-frequency current in ozena is difficult to understand. In addition to its trophic, congestive, cicatrizing and bactericidal effect, the action of nascent ozone may come into play. An effect upon the endocrine sympathetic system appears undeniable, and the results support Halphen's hypothesis of the sphenopalatine origin of the affection. The action is rapid and complete, irrespective of the degree of the lesion. It seems somewhat more prompt in the dry than in the moist forms. The odor entirely disappears. In a very small number of cases weekly lavage may still be necessary. Leroux is convinced that no other treatment of ozena is as effective as the high-frequency current.

Sensitive Points of Nasal Mucosa.—Practically all of the older and many of the recent texts treat of sensitive areas of the nasal mucosa, especially in connection with hay fever, asthma and the like. Killian and others have attempted to specify which areas are sensitive, but we are not now interested in such details.

Desensitization of the nasal membranes is best accomplished with diathermy obtained from the Oudin terminal. We are making use of a newly devised electrode and holder which has been perfected in the course of our experimental work on hay fever and asthma. In order properly to desensitize the nasal mucosa, several applications may have to be made, individuals differing in this

respect. The electrode, which is non-vacuum and shaped to fit the nasal chamber without discomfort, is inserted and gently moved about. During the first part of the treatment, the electrode is introduced with the pointed end directed upward, and later on, with the end directed downward. By this manipulation, the entire surface is treated. The current should be weak and always under control. The patient may cough violently at first, feel uncomfortable and complain of lachrymation and dizziness. None of these symptoms are sufficiently important to interfere with the carrying out of the procedure. At the second or third treatment, complete tolerance will be established. It is better to overtreat when complete densitization of the membranes is desired. Fifteen to twenty minutes is not too long for a single application. Intranasal ultraviolet radiation should conclude each séance.

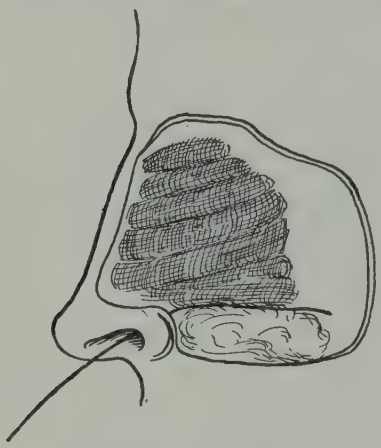

Fig. 60.—Ionization of nasal mucosa.

Purulent Rhinitis.—Especially in children or young adults, when it is inadvisable to operate intranasally for obstruction due to enlarged boggy turbinates, or to straighten the septum, galvanism represents a valuable aid in combating this affection. We find it satisfactory to pack the nose with long, narrow strips of gauze saturated in a weak zinc solution. The end of the wire

leading from the galvanic machine is embedded in the wet nasal packing. (Fig. 60). Not more than 5 to 6 milliamperes are required and the duration should not exceed fifteen minutes. The frequency of treatments depends on the progress made.

CHAPTER XVII

THE TURBINATE BODIES AND SEPTUM

Hypertrophied Inferior Turbinates.—For this condition we have replaced the older method of galvanocauterization with diathermy. Oudin sparks from a non-vacuum electrode will greatly influence the size of the turbinate bodies. If preferred, a copper wire with a bifurcated tip in a suitable insulated holder (Fig. 61)

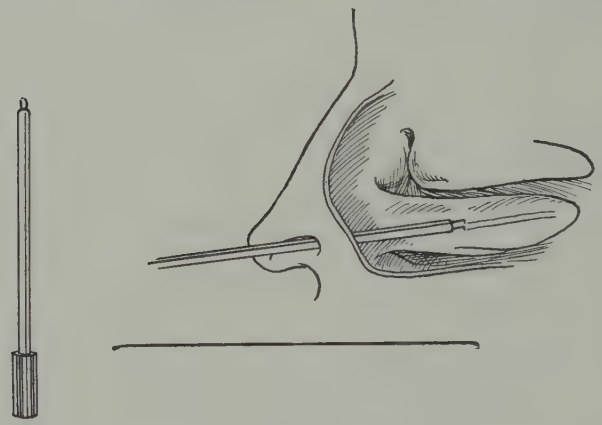

FIG. 61.—Electrode with bifurcated tip for fulguration of turbinates.

can be used, as the entire procedure is one of mild fulguration which is always under the control of the eye. The instrument can be carried to the posterior end of the inferior turbinate and the fulgurative action carried along a straight line to the anterior portion. This method is

a distinct improvement over the older ones, and, in most instances, can be performed without the use of an anesthetic. In fact, a local anesthetic tends to shrink the tissues, disguising the true size of the parts to be treated. If a local anesthetic is occasionally necessary a 4 per cent solution of apothesine on cotton pledgets, inserted and left in place for twenty or thirty minutes before the operation is performed, will suffice, or the apothesine may be gently rubbed into the bony structure according to the method suggested by Novak.

The electro-cautery still has a place in the treatment of hypertrophied turbinates. Brooks calls attention to the use of the insulated vacuum nasal electrode, which, when inserted into the nasal chambers for ten minutes and connected up from the wave current to a static machine with the ground chain off, has been found to reduce swollen and congested turbinates.

Another method for the treatment of hypertrophied inferior turbinates was suggested by Prof. Leduc, and is known as *zinc electrolysis.* The technic is as follows: Introduce a zinc needle into the soft tissues, at the anterior extremity of the turbinal, and pass close to the bone horizontally backwards toward the nasopharynx. Proper anesthesia is necessary. A strong darning needle plated with zinc and with a copper wire twisted into the eye, which is embedded in a short stick of sealing wax as handle, will be found convenient. The current should be turned on gradually, cautiously increased to 15 ma., and allowed to act for twenty minutes. It is most important to avoid any loose connections, as severe pains referred to the teeth will be felt on the make and break of the current. At the end of the treatment the current is gradually decreased, and then reversed and

allowed to flow for about five minutes to loosen the needle by the formation of Na OH around it. If the needle is roughly pulled out, considerable bleeding will follow, and the result of the treatment is not likely to be satisfactory. The shaft of the needle, where it will come in contact with the mucous membrane, should be insulated by painting with shellac or sealing-wax, and the insulated portion should extend a short distance into the tissues, to avoid the formation of a small slough and ulcer on the surface of the mucous membrane at the point of entrance. Beyond putting a little cotton into the nostril for a few hours, no after-treatment is required. Naturally this method of treatment is not suitable for cases in which the obstruction is due to bony irregularity. (Friel.)

Epistaxis.—This condition if caused by small varicose veins at the lower end of the nasal septum may be treated by the method described in the preceding section. Cotton soaked in zinc solution can be held by a metal rod against the bleeding point, and the current applied for two to three minutes.

The Middle Turbinates.—Hypertrophied and bullous middle turbinates sometimes respond without treatment of any kind when local irritation of the nasal membranes as a whole has been removed as much as possible. Chronically infected nasal membranes are always difficult to treat if some focus higher up persists and remains uncorrected. There are many patients, however, in whom no foci can be demonstrated, and the infectious state of the membrane must be attributed to local causes. Often when the local disease is controlled, the middle turbinates reduce in size. The use of electrotherapeutic measures, especially cauterization of the middle turbinates, is con-

sidered a rather hazardous undertaking and must not be attempted indiscriminately. We hesitate to advise it at all, although some reports have recently appeared in which an improved electro-cautery has been successfully employed in fifty selected cases involving the middle

Fig. 62.—Insulated nasal snare. A, Attachment for cord.

turbinate. The anterior and posterior ends of turbinates may be removed bloodlessly by coagulation-dissection with an insulated snare. (Figs. 62 and 63.)

Until an absolutely harmless method shall be found we recommend argyrol tamponage followed by quartz light (Fig. 64) intranasally, from the water-cooled lamp. In the absence of complicating pathology prolonged daily treatments will yield good results.

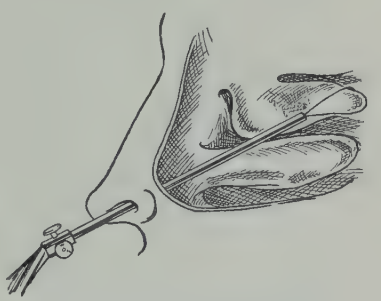

Fig. 63.—Snare in operation.

The Septum.—Submucous resection of the nasal septum has been perfected to such a degree that there appears to be no occasion for electrical methods for pathologic conditions involving this structure. However, some rhinologists prefer electrolysis in selected cases. The recent litera-

ture on this subject is meager. Coleman's work, published in 1912, contains the following conclusions:

1. Strictly cartilaginous spurs can be thoroughly removed by electrolysis, one, two, or at most three operations being required.
2. The amount of reduction by electrolysis is commensurate with the portion of cartilage of which they are composed.

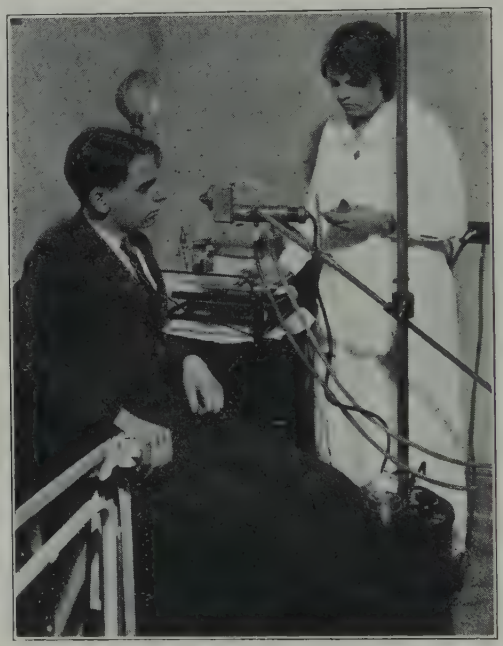

FIG. 64.—Intranasal ultraviolet irradiation with quartz rod applicator.

3. Spurs, composed wholly or largely of hard bone, cannot be successfully treated by electrolysis.
4. Electrolysis is powerless to correct deviated septa of any form.

It must be realized that electrolysis had been heralded as a treatment for septal conditions prior to the introduc-

tion and perfection of the submucous operation. We do not oppose the use of electrolysis, but experience has proven that it is inferior to surgery.

Nasal Synechiae.—This condition may be treated by inserting zinc needle electrodes into the synechiae. Several insulated needles are bound together, the outer one is connected to the positive pole and the middle one to the negative. Ten milliamperes for thirty minutes are employed, with subsequent reversal of the current for a like period. Complete disappearance of the synechiae will require from one to two weeks. This treatment, if properly carried out, is superior to excision. The operation should be performed under local anesthesia.

CHAPTER XVIII

THE ACCESSORY SINUSES

Acute Sinusitis.—The rationale for the employment of radiant heat-light in acute sinusitis is well established by its analgesic, decongestive and absorptive action. Radiant heat-light is superior to other heat-producing agents because its effects are more uniform.

FIG. 65.—Direct raying of nose by means of bilateral speculum.

Ultraviolet light is applied intranasally (Fig. 65) for its lethal and stimulating actions. Ellis and Wells state that the lethal action is a direct one of the rays upon the bodies of the bacteria, and is not due to the formation of germicidal substances, such as hydrogen peroxide. It has been established, further, that the bactericidal action of light was due to the rays of short wave length, including the ultraviolet; and that dried matter was at least as easily sterilized by the rays as moist matter. (The lethal action of ultraviolet rays is also termed "abiotic" in contradistinction to their "biologic" action.)

Medical diathermy produces an increase in temperature

without destructive effect. It is applied to a sinus for its deep heating action and because it is decongestive to the mucous lining involved, and probably to some extent absorptive. Analgesic properties as well as an ability to induce hyperemia and stimulate repair are also to be noted.

Both local and general measures are called for since constitutional symptoms are almost invariably present.

We have attempted to do away with shrinkage by cocaine or adrenalin, or both, substituting argyrol tamponage (Dowling treatment). Diathermy directly over the sinus is of decided benefit, but must be used with caution. Good drainage should first be established intranasally. It is better to wait until the acute symptoms have somewhat subsided before diathermy is applied, and until such time, radiant heat-light and the other measures suggested will be found of great value.

Vacuum or non-vacuum electrodes for sinus affections

Fig. 66.—Modified diathermy of frontal sinuses.

(Fig. 66) may be used with a monopolar current. Modified diathermy suggested by Brooke, should also be tried if direct diathermy cannot be administered.

The technic for direct diathermy to the different nasal

Fig. 67.—Direct diathermy to antrum.

accessory sinuses is illustrated by the accompanying photographs. (Figs. 67, 68 and 69.) With the head band and special electrodes, the application of direct diathermy for sinus disease has been greatly facilitated and the results markedly improved.

Chronic Sinusitis—Chronic Antrum Disease.—From the standpoint of electrotherapy, it is unnecessary to consider each sinus involvement by itself, because the principles of the treatment are more or less similar.

FIG. 68.—Electrode in place for treatment of frontal sinus.

Medical diathermy, applied by means of a special electrode for the particular sinus involved, will relieve pain and promote drainage. The subsequent measures should include the Dowling treatment and ultraviolet light. This combination is indicated in chronic cases, in which

for some reason intranasal surgery is contraindicated. Improvement has been obtained in a large percentage of patients, and definite cures have been observed in quite a number.

While no conflict exists if suction or irrigation of the antrum is necessary, the latter procedure is now rarely practiced for therapeutic purposes. If suction is used, it should be done by the capillary method.

Ethmoiditis—Polypoid Degeneration.—Beck, Pollock and Lederer report the use of the electrocautery by Lederer in 50 instances of strictly polypoid cases where radical removal of the middle turbinate and a thorough exenteration and re-exenteration of the ethmoid cells has failed to check the recurrence of the polyps. These cases were of the purely non-suppurative hyperplastic variety. The literature contains reports of cases in which meningitis followed cauterization of the middle turbinate, but these operations were performed in the presence of suppuration, while the series reported by Beck and his associates, precluded such involvement. The sequelæ and complications which have been ascribed to this form of procedure have had accordingly a deterring influence which was not justified by the actual facts. A warning issued in connection with this method is

Fig. 69.—Application of electrodes for treatment of sphenoid area.

important, "We feel that, by the improved technic and the careful selection of cases, this method (of electrocautery) may come into use again. However, being fearful lest its indiscriminate use lead to mishaps which would again discredit this operation, we are working up a larger series of cases and will subsequently present it in detailed form." (Beck,, Pollock and Lederer.)

Post Operative Treatment of Sinuses by Zinc Ionization.—Fox reported a refractory case of antrum infection which persisted under ordinary measures of treatment for one and one-half years. Irrigations were combined with zinc ionization. Five such treatments were administered at intervals of four, sixteen, four and seven days: usually 3 ma. for 10 minutes with a 1 per cent zinc sulphate solution. The positive zinc electrode was inserted into a No. 17 French soft rubber male catheter, so as not to protrude from it. After the last of these treatments, which were accompanied and followed by considerable pain, the patient went on three weeks' vacation, at the end of which she reported that, following the last treatment, the discharge was very much increased, then disappeared entirely. A month and a half later, the sinus was still clear and without discharge. Fox suggests that it might be preferable to begin with a 0.5 per cent solution, until the patients have learned what is expected of them, so that less irritation is caused if it should run into the throat.

Malignant Growths of the Paranasal Sinuses—Treatment by Irradiation, Electrocoagulation and Other Methods.—After reviewing the work of others, Stevens reports cases of his own, illustrating some fairly successful results of treatment by radiation and electrocoagulation. While admitting that he cannot give a hopeful

report on the treatment of malignant disease of the sinuses, he feels that with the present knowledge of applying radium, deep Roentgen therapy and electrocoagulation, a method might be standardized which would give promise of good results. He suggests that in cases which present the definite diagnosis of sarcoma, no piece of the growth should be removed for microscopic examination; but if deemed advisable, a section should be removed with the assistance of electrocoagulation, followed immediately by proper deep therapy, giving as nearly homogeneous irradiation as possible. In all other cases, after painstaking attempts to make a clinical diagnosis by various methods, a section can be taken for microscopic examination if the wound is closed by electrocoagulation, followed immediately by careful irradiation. Operation by electrocoagulation should follow promptly, if it is possible to use this method in the region concerned. Recurrence should also be treated by electrocoagulation and with radium. Cases with adenopathy or metastases are probably hopeless, and should be accepted only with the distinct understanding that treatment will be only palliative in character. Devitalization of bone must be expected where electrocoagulation is used. This may also follow heavy radiation with either radium or the Roentgen rays. The bone can be easily removed several weeks later.

CHAPTER XIX

TUMORS OF THE NOSE AND FACE

Epithelioma.—Two principal types are recognized, *viz.*, the so-called basal cell epithelioma and the squamous cell epithelioma. It has been pointed out that practically all of the epitheliomata on the skin of the face above a line drawn from the angle of the mouth back through the auditory canal are of the basal cell type. The squamous cell epitheliomata are usually found at the mucocutaneous junctions of the lips and inside the mouth. This latter type gives the greatest difficulty in management and often taxes the surgeon's ingenuity to determine what method or combination of methods to employ.

Epithelioma Involving the Nose—Method of Applying Surgical Diathermy.—Epitheliomata frequently involve the nose and when treated early by surgical diathermy and radiotherapy, a good prognosis may be anticipated. The operation may be performed under local anesthesia, though occasionally general anesthesia may have to be resorted to. The technic now used is more or less universal and differs only in slight details. The indifferent electrode, of block tin, is placed in contact with the patient's bare back or abdomen, usually at some distance from the field of operation. The active electrode is placed in contact with the tissue to be destroyed. Various styles of points and electrodes and

holders are now on the market and the operator must select the one best suited for the individual case. It is important to destroy the tissue to a sufficient depth and to coagulate by blanching, not charring, the entire area. Often the destroyed mass will come away immediately, but when it is large, separation may not occur till the wound is redressed some hours later. The odor from the slough can be controlled by application of a weak mercurochrome solution and a few exposures with the water-cooled lamp. This latter step is an excellent sterilizer and hastens the formation of granulation and healing. Care must be taken in dressing the wound that the new granulations are not pulled away and for this purpose any desired method may be employed. The simplest way is to use a lubricant, such as sterile vaselin, but as healing progresses the wound should be exposed to the air as much as possible and sealing it with dressings or heavy lubricants is not advisable. Subsequent treatment with radium or the X-ray or both is not always necessary, but this must be determined by the surgeon in each individual case.

Briefly, the advantages of the method are:

1. It is a procedure which can be accurately controlled.
2. It is bloodless and painless.
3. There is practically no after pain.
4. Scar formation is reduced to the minimum.

Clark lays emphasis on one factor of the treatment, especially when large areas are involved. One should always begin by throwing a line of coagulation around and beneath the lesion or mass to be treated so as to cut off lymph and blood drainage from the involved area. One should guard against overtreatment, bearing in mind that tissue destruction goes far beyond the area

of blanching. It is quite obvious that perfection in technic must be acquired by actual experience. The large clinical material available in medical centers should be utilized at every opportunity for study and observation.

Tumors About the Nose, Face, and Lip.—The treatment does not vary from that already described, except that the location of a tumor mass has much to do with the depth of tissue to be destroyed. In cases of long standing the presence of glandular involvement must be taken into account for subsequent attention in order to obtain a radical cure.

The question has frequently arisen whether electrocoagulation is the method of choice for benign growths. Plank is of the opinion that "the surgeon will find high frequency currents best adapted to malignant lesions and, to a limited extent only, to those which are benign and below the integument. Benign growths below the surface usually can be excised and the skin closed with a minimum of scarring. If coagulation were used in these cases, it would be necessary to destroy the skin or leave the wound open for removal of the slough which would delay healing and cause contractions. Essential structures as blood vessels and nerves running through or close to the growth would be unnecessarily destroyed and in all cases there would be a slough for which drainage would have to be provided."

We are fully in accord with this author and prefer operative surgical measures in almost all cases of benign tumors.

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PART FIVE

TREATMENT OF DISEASES OF THE MOUTH, PHARYNX AND LARYNX

CHAPTER XX

THE MOUTH

Pyorrhea Alveolaris.—While it is appreciated that pyorrhea alveolaris belongs in the realm of oral surgery, and that the dental surgeon would be the logical one to discuss it, one need not apologize for including some brief remarks on this extremely important subject. In the absence of a standardized treatment for pyorrhea, or at least one that is satisfactory, ultraviolet light will eventually be recognized as a remedy which approaches being a specific.

Folstein very recently surveyed the subject at great length and wrote: "Having reviewed the different methods of treatment, observed the various disadvantages of each, and realized the uncertainty of results in each method, it became a matter of necessity to arrive at some method which would procure results, not in the isolated cases, but in practically all cases." This writer emphasized that he has chosen quartz light therapy because it is the only method which has given, in his hands, consistently favorabue results as a cure for pyorrhea. His technic, worked out in steps, follows:

1. X-ray examination of the teeth and notation of all pathologic facts.
2. Removal of bridges imringing on soft tissues and improperly placed fillings.
3. Scaling of teeth as thoroughly as possible.
4. Application of ultraviolet by compression method.

No more than three or four teeth are treated at one time, and each area is treated both facially and lingually until a marked reaction occurs.

The technic advocated by us differs from that commonly in use. We prefer to give a sufficient irradiation to produce a marked gingival reaction to each area at one sitting instead of a gradual, step by step, increase, taking up several treatments to obtain the desired effect. It is essential to know the blistering time on mucous membranes of the water-cooled burner. This point has been strongly emphasized by Sampson, who wrote: "A violent *tissue reaction* is necessary if the treatment is to succeed." Sampson advises that if your lamp will blister in forty seconds then give 70 or 80 seconds contact-under-

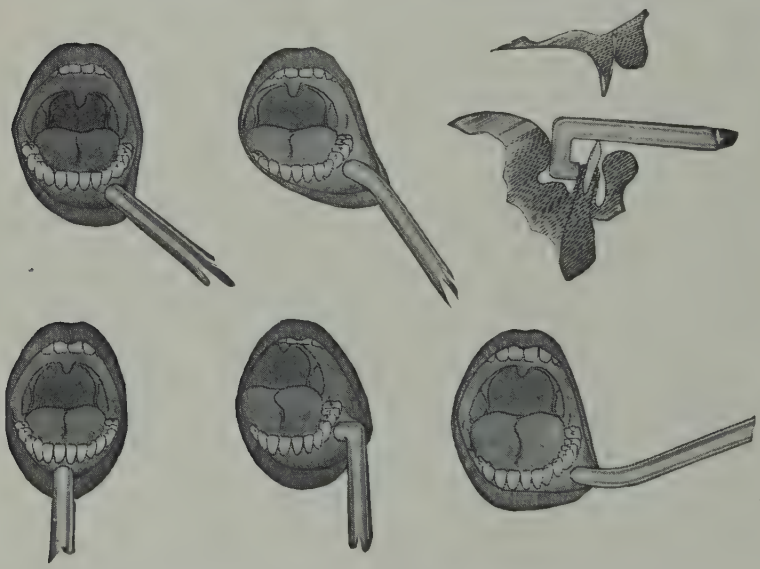

Fig. 70.—Quartz applicators in the different positions for treating pyorrhea.

pressure exposure or more. The pressure should be just sufficient to whiten the gum under the end of the applicator. (Fig. 70.) The applicator used in pyorrhea work should be all quartz. Sampson's technic for treating pyorrhea is undoubtedly the most perfected at the present time.

Lippman, at the Naval Hospital, Brooklyn, used ultraviolet in many oral conditions. In reporting on his work he remarked: "Suitable applicators were designed, and a series of cases, ranging from simple gingivitis to morbid pyorrhea, was placed under treatment. Where much loss of process existed, no marked changed was noted in the firmness of the teeth. But in all cases, purulent discharge stopped and the gums resumed a healthy tone. Bacteriologic examination exposed the presence of Vincent's bacilli, which proved negative after the fifth treatment in the less severe cases, and after the tenth in the worst.

At that time treatment was commenced with a one minute exposure, and increased daily by one minute for four days, after which five minute exposures were made. Since then the light has been applied in cases other than pyorrhea, such as Vincent's Angina, cellulitis, periostitis, neuralgia, post-operative pains, and in all post-operative procedure about the mouth, with most gratifying results.

Bovie believes that the stimulation of the tissues of the gums is responsible for such curative effects as ultraviolet light affords.

Stomatitis—Vincent's Stomatitis.—Stomatitis, if due entirely to local causes, responds readily to quartz rays. Good results have been obtained in many cases. Gilett reported a case of Vincent's stomatitis, or trench mouth, cured after eleven days in which only seven treatments

Fig. 71.—Tuberculous ulcer on side of tongue.

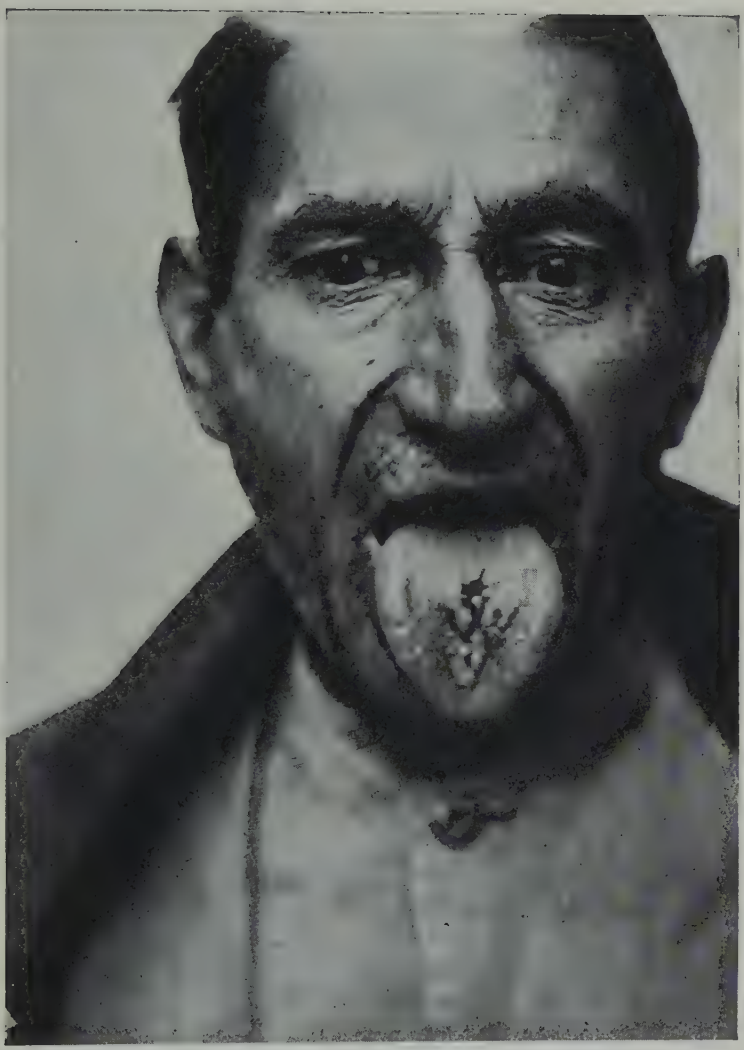

Fig. 72.—Tuberculous ulcer on dorsum of tongue.

were given. Typical Vincent's angina is treated satisfactorily with ultraviolet light for its local effect on the site of infection, but general measures are also necessary.

Ulcerations of the Tongue.—Here again, quartz light is of value. The application should be made at a distance of four inches. It is far better to undertreat *these* cases than to produce a violent reaction, which, while harmless, is very distressing to the patient. Exposures should be given on alternate days, gradually increasing the time of each treatment. Usually not more than four to six are required in all. Removal of the immediate cause is imperative if recurrence and subsequent complications are to be avoided. Frequently either sharp or broken teeth or imperfect dental work is the source of constant irritation which leads eventually to ulcer formation. (Figs. 71 and 72.)

Epithelioma of the Tongue.—The technic for electrocoagulation of accessible neoplasms has already been given in the preceding chapter (Fig. 73). General anesthesia is preferred for lingual operations. We are in the habit of using chloroform, although either nitrous-oxide and ether, or the so-called gas-oxygen-ether is satisfactory, if administered by an expert. The hazard of fire when using any inflammable product in connection with surgical diathermy must always be remembered.

Radium needles have been used with some good results in epithelioma of the tongue, and undoubtedly a certain class of these cases is best suited for this form of therapy. Simpson advocated the implantation of bare glass tubes containing radium emanation, and cites 30 cases treated in this manner. The implantation is preceded by surface radiation, after which the tongue is anesthetized. Then, infiltration with from 5 to 38 glass ampules, each

containing 0.5 mc. of radium emanation, the number of ampules depending upon the size of the tumor. Simpson stated in his report that he has not yet seen a lesion that was made worse by this treatment, and there has been no failure of any tongue lesion to heal when the growth could be treated under direct vision. In two cases in which the base of the tongue was involved, the lesion did not completely heal, due perhaps to faulty technic. The cervical glands, whether palpable or not, should be treated with very heavy surface radiations. It is undeniable that there are some disadvantages in radium emanations. The chief objections are the pain incident to the treatment, and the likelihood of hemorrhage from the lesion as a result of injudicious attempts to remove the slough.

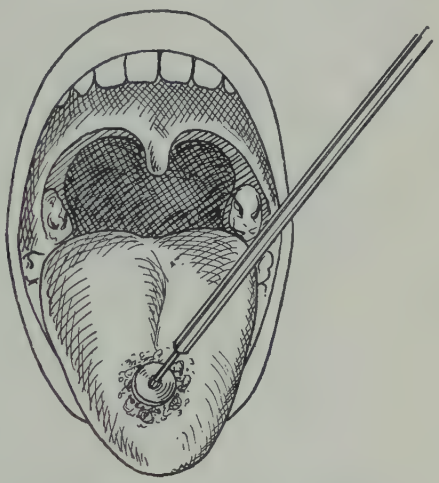

FIG. 73.—Surgical diathermy (electrocoagulation) with button electrode.

CHAPTER XXI

THE PHARYNX

Pharyngitis.—In this, as in almost all infections, no treatment is rational without the removal of the focal cause. Persistent sinus or nasal infection, unattended to, will produce a chronic pharyngitis which very often stubbornly resists all recognized procedures. The nose is best treated by argyrol tamponage and quartz light by the direct method. The pharynx is also irradiated, indirecty, with the solid quartz applicator. (Fig. 74.) If the tonsils are diseased, either medical or surgical measures should be resorted to, and often the pharyngitis will clear up without any other treatment. One must not forget, here as elsewhere, that systemic diseases, such as syphilis or tuberculosis, are not infrequently sources of infection, requiring appropriate constitutional treatment.

Tonsillitis.—An interesting controversy regarding the applicability of non-surgical therapy has divided the profession. Light, electrocoagulation and electrodesiccation, and other electrical methods have their place. The personal equation plays a rôle, for a method in the hands of one laryngologist may prove much more satisfactory than in the hands of another. We prefer to submit the available material on this subject, and let the reader choose the method.

Acute Tonsillitis.—The treatment is primarily consti-

tutional, especially so if a rise of temperature exists with other systemic symptoms. Rest in bed, catharsis and other accepted measures are not to be replaced, but supplemented by electrotherapy. Radiant heat-light is often gratifying if the patient is forced to his bed. If

Fig. 74.—Irradiation of pharynx with ultraviolet light.

the constitutional symptoms are negligible, ultraviolet light to the tonsils will promptly reduce the inflammatory process. This procedure may be preceded by a topical application to the surface of the tonsils of some aniline dye, such as a five per cent mercurochrome solution. Care must be taken not to give too intensive raying, lest a marked reaction follow. General body radiations

for their alterative and tonic effects are sometimes valuable in shortening the course of this illness

Chronic Tonsillitis—Non-surgical Treatment.—It is well recognized that the bactericidal action of the ultraviolet rays is, what may be properly termed, "surface action." In other words, the rays do not penetrate to a depth more than a few millimeters, and therefore are incapable of sterilizing the entire tonsillar substance. Ultraviolet rays, without the use of other agents, have been beneficial in the treatment of various forms of chronic tonsillitis. (Fig. 75.) It is admitted that after numerous applications a shrinkage of the tonsils is noticeable, but few, if any, are willing to state that permanent results have been obtained. The fact is that the water-cooled lamp is a good pallitative agent in chronic tonsillitis, but its scope of usefulness is limited.

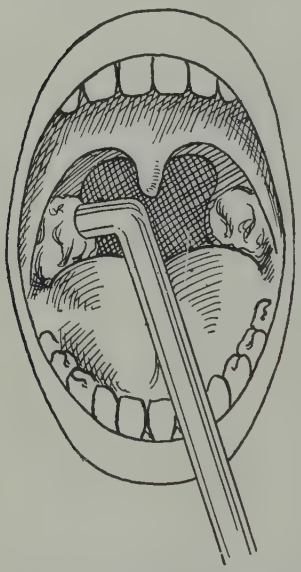

Fig. 75.—Curved pharyngeal quartz applicator in position for irradiating tonsil.

Denman has suggested the combined use of X-rays and ultraviolet radiation, and we believe that this combined method is superior to the X-rays alone. Witherbee and others have demonstrated that exposure to the X-ray results in absorption of the lymphoid tissue of the tonsil, and a shrinkage of the entire organ. Denman employs what he calls his "triad" of radiant forces, condensed, water-cooled ultraviolet rays for sterilization, diffuse

ultraviolet rays from the Alpine Lamp to promote metabolic reaction against infection, and X-rays to absorb lymphoid tissue and shrink the faucial and lingual tonsils.

The *modus operandi* is explained thus: As the lymphoid tissue is absorbed by the action of the X-rays, and the tonsil contracts, the crypts and fissures are obliterated, and the pus is squeezed out like fluid from a sponge, into the surface of the organ, where it may be seen as the treatment progresses. The tonsil is eventually converted into a small, hard, fibrous nodule, devoid of lymphoid tissue, and cleaned of infection. In short, the treatment does for the diseased tonsil, in a few weeks, what nature does to the normal by the time adult life is reached.

The technic of Witherbee and other pioneers in X-ray therapy of tonsils is: 10 inch spark gap; 10 inch distance; 1 mm. Al., ½ mm. Cu. and a piece of sole leather as filter; time, four minutes. Weekly treatments are given for a sum total of fifteen minutes, after which the séances are repeated once every two weeks. Ten treatments usually comprise a full course.

Tousey's technic is described in his monograph as follows: 6 inch spark gap, 3 ma., 13 inch distance, 3 mm. aluminum, ten minutes. The application is external; the chin up and the head turned to the opposite side. A protective cylinder 3 inches in diameter limits the rays to the region behind the angle of the jaw. One treatment is sufficient for one tonsil, and where both are affected, each side of the neck may receive such an application at a single session or at different sessions.

Blaine administers treatments once every seven to ten days until a series of eight has been given, after which

a period of observation of 6 to 8 weeks is required to determine results; the softer the tonsil the more marked the improvement. Children respond much more quickly than do adults. In some cases a subsequent raying is given to complete the treatment. The X-ray formula consists of 5 ma. at 100 kilovoltage (sphere-gap), 30 cm. focal spot distance through 3 mm. aluminum filter, for 5 minutes, using a circular lead diaphragm opening of 5 cm. diameter at 15 cm. from the target. The patient lies prone, with head turned sharply to the right or left according to which tonsil is to be rayed, and both sides are irradiated at each treatment. The central beam is directed to pass into the side of the neck just posterior to the angle of the jaw. This will include the tonsils, adenoids and lymphatics of the nasopharynx. No sheet lead or similar protection is used over the patient's head.

This technic differs in very few details from that of Witherbee and others. We have employed a similar procedure, but prefer to have the patient sitting up during the actual radiation, the same as is done in treating deafness.

The advocates of X-ray therapy for diseased tonsils, adenoids or pharyngeal tissue, base their preference for the non-surgical method on the results obtained in large series of cases.

Before passing this subject, it may not be amiss to discuss the investigations of MacCready, who brings out one feature omitted by others who have conducted work along these lines. MacCready is firm in his belief that Roentgen ray treatment causes a definite shrinkage of the lymphoid tissue of the tonsils and adenoids, but states that, on the other hand, bacteriological and pathological studies show that Roentgen ray treatment has no effect

on local sepsis in the tonsils and adenoids. Accordingly Roentgen treatment would be beneficial only to the type of patients who have hypertrophy of the tonsils without sepsis. The determination of infective foci from the history and the presence of complications is, of course, a simple matter.

This report seems to place on a sound basis the use of X-rays in tonsil work, which may be accepted as a guide in the treatment of tonsilitis.

Rott, in a critical survey of Roentgen therapy for diseased tonsils, quotes Nuzum, Lederer, Bordern, Babcock and Shurly, to show that roentgenotherapy cannot be relied upon to effect a reduction in the size of diseased tonsils nor to rid them of pathogenic bacteria. Nuzum found that the size was reduced in only 16 per cent of 218 pairs of tonsils, and that hemolytic streptococci were permanently removed in only 50 per cent of 32 patients. Lederer observed a slight change in size only in case of children with the usual hypertrophied tonsils; he reported also alleviation of subjective symptoms in such cases. But patients with recurrent attacks were benefited only temporarily, and fibrotic tonsils appeared to be smaller and more normal in appearance, but on being removed afterwards, they proved to be unchanged and filled with pus and cheesy débris. Babcock showed the futility of depending upon this method in chronic infected tonsils, especially of the small fibrotic type. While admitting that, in some cases, delay of surgical intervention might be justified while Roentgen therapy is given a trial, Rott insists that tonsillectomy remains the one really adequate method of removing diseased tonsils, and that in certain cases of severe systemic disease, delay may be disastrous.

Adenoids.—The non-surgical treatment is similar to that discussed in connection with hypertrophied or diseased tonsils. In fact, the treatment of the tonsils usually includes the adenoids. Occasionally, adenoid tissue can be shrunken and sterilized by the application of ultraviolet light without X-rays. A curved pharyngeal or post-nasal quartz applicator is employed and short exposures are administered. The operator must use caution lest severe reactions occur from exposure of the adjacent pharyngeal tissues. These reactions have been known to develop and are very annoying to the patient because healing is usually slow. Should such a contingency arise, the use of strong alkaline washes and lozenges containing orthoform are recommended. These are analgesic in their action and give the patient comfort until actual healing occurs.

Tonsils—Surgical Diathermy.—Although much has of late been written on tonsil coagulation and tonsil desiccation, few of the reports can be accepted as authoritative. Some employ the method exclusively and have, as a result, discarded the orthodox tonsillectomy, while others have adopted this technic in selected cases only. On the other extreme are the disbelievers, recruited from those who have tried the method and discarded it, and from others who have never used it and are prejudiced on theoretic grounds.

Clark has described what he called a desiccation method of destroying tonsillar tissue. It involves the use of an ordinary knitting needle bent at the end, which is held in the fulguration handle. The needle, carrying a Tesla current, is introduced into the tonsillar substance. The Tesla current is said to produce an effect which is more sharply localized. The edema is less than with the

D'Arsonval coagulation, and in general the method is more accurately under control.

Some operators do not infiltrate the tonsil for anesthetic effect. Thometz suggested powdered anesthesin (Metz) blown into the throat and over the tonsil, followed by swabbing with cocaine flakes. The infiltration method is condemned by him on account of the fact that moisture favors the diffusion of heat.

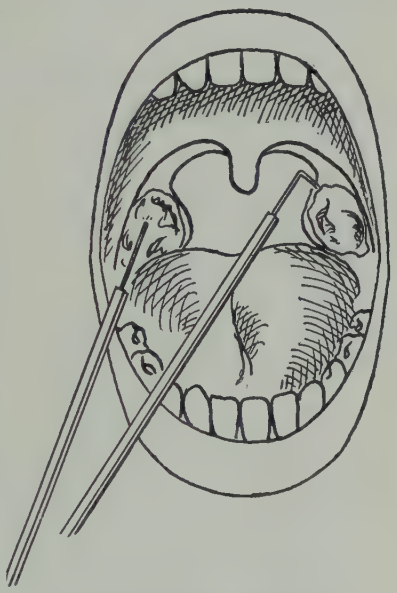

Fig. 76.—Electrocoagulation of tonsils.

Various types of electrodes for tonsil desiccation and tonsil coagulation are now on the market. When the operator is ready to proceed, the patient is made to hold the auto-condensation handle which is attached to the meter of the diathermy machine. The other cord, which is attached to the electrode, is fastened to the Tesla outlet. About 500 milliamperes of current are sufficient for this work. A foot switch is always where the operator can control the current. The auto-condensation handle connected to the meter and held by the patient acts as a ground. The technic as given here is one which has been adopted and used extensively by Thometz and others.

Elmer prefers electrocoagulation (Fig. 76) to electro-

desiccation. He uses one-half per cent solution of novocain or procain to which he adds five grains of magnesium sulphate and five grains of sodium chloride to each ounce of solution, and infiltrates in the usual manner. The patient holds the large electrode and the coagulation is performed by inserting the needle into the tonsil, following it all the way around until a grayish discoloration appears. A very large tonsil contraindicates this method. Elmer reported the occurrence of Vincent's angina in some cases, but claims definite advantages for the method. Some of them are: absence of hemorrhage and danger of post-operative pneumonia and shortening of convalescence.

Plank claims that hospitalization is unnecessary, as it is purely an office treatment, and that sterilization of the throat is performed by the procedure itself—excessive heat. Most workers maintain that post-operative sterilization is best accomplished by the use of actinic rays from a water-cooled, quartz-mercury lamp.

Novak attempted to apply surgical diathermy to the tonsils in a large series of cases, but was reluctant to continue after seven cases had been so treated.

His observation took into consideration, (1) the immediate effects of the operation; (2) the extent of the post-operative inflammatory reaction, *i.e.,* the amount of extra tonsillar tissue involved; (3) the degree of inflammatory reaction, and (4) the early post-operative symptomatology.

Further considerations were: (1) the extent and degree of cicatrization within and outside of the tonsillar fossa; (2) the damage, if any, to the palatopharyngeus and palatoglossus muscles; (3) the impairment, if any, of the function of the soft palate; (4) the frequency of otitic

complications due to possible damage to Rosenmueller's fossa (5) the effect on the voice and deglutition, and (6) the thoroughness of the destruction of tonsillar tissue.

The technic employed by Novak was as follows: After a topical application of 4 per cent cocain solution, the peritonsillar tissue was infiltrated in the usual manner with 1 per cent procain. A flat electrode 12 by 12 inches, well moistened with tap water, was applied to the patient's back. This indifferent electrode was connected with a high-frequency apparatus, generating the D'Arsonval current with a frequency rate of a million or more oscillations per second, and delivering an amperage of from 1 to 4,500 milliamperes. The active electrodes were of two types, namely, the needle, and a flat button electrode of a diameter of 7 mm. The needle was used in one case, penetrating into the substance of the tonsil, and carrying an amperage of 400 milliamperes. It was inserted into three portions of the tonsil, and the current turned on for fifteen seconds in each place sufficient to blanch the tonsil. The other cases were treated with the button electrode and with currents for the respective tonsils of from 400 to 1,500 milliamperes, and for the periods of time sufficient to coagulate the tonsils. This time varied from 50 seconds to 10 seconds, respectively. The greater the amperage, the shorter the period of application.

The patients in general were comfortable during the operation. No bleeding whatever occurred. The technical skill and dexterity for the operation is no greater than that required to apply a swab of silver nitrate solution to a tonsil, assuming familiarity with the technic of electrocoagulation.

Contrary to the good results reported by the advocates of surgical diathermy of tonsils, the series of cases operated upon by Novak did not convince him of the effectiveness of the method. The patients, without exception, embarked upon a stormy experience within a few hours after operation. There were distressing pain, extreme difficulty in swallowing and impairment of speech. These symptoms subsided after six days. Special note was made of the reactions: marked edema of the pillars, sloughing of tissue, intense edema of the pharynx, uvula, pillars and soft palate, and trismus; and in a few of the patients, the lower pole of the tonsil was still present.

The conclusions of Novak are quoted verbatim: "Assuming that electrocoagulation of the tonsils is a simple, bloodless operation, and assuming, moreover, that the ultimate results of this operation might be satisfactory, the very severe reaction, the great pain, the toxemia and the extreme discomfort of the patient almost immediately following operation are sufficient reasons for condemning the method. Furthermore, there is no accurate way of determining the dosage to be applied. Nor is it possible to apply the heat with sufficient accuracy to insure the destruction of only the tonsillar tissue. There is no gauge by which the penetration of heat, through the tonsil and up to the capsule only, can be measured. The heat necessary to destroy the tonsil is great enough to penetrate and damage the surrounding tissues. If the aim is merely to obliterate a single crypt, then there is no assurance that a purulent pocket in the fundus of the crypt is not sealed in by a covering of resulting scar tissue. Whatever logical basis electrocoagulation of diseased tonsils may have, or appear to have from a theoretical standpoint, is far overshadowed by the unfortu-

nate and unsatisfactory results obtained in actual practice."

The author does not argue the fact that ordinarily a small series of cases is insufficient for a clinical test. In this instance, however, it is his opinion that sufficient evidence, as a result of the experimental work, is presented to label electrocoagulation of tonsils an unsatisfactory procedure, both from the standpoint of the surgeon and from that of the patient, and therefore cannot in any manner compete with tonsillectomy.

Coagulation-Dissection of Tonsils with a Modified Beck Tonsillectome.—Within the past few years reports have appeared on the use of the high frequency or "radio" knife for the dissection of tonsils. The tonsils are removed *in toto* by a process similar to blunt dissection, while the "radio-frequency knife" effectively controls bleeding and seals lymphatics. This method has many disadvantages. First one has to contend with a shower of fine sparks; secondly, a large blood vessel which has been severed may bleed for some time despite vigorous sparking. Third, the dissection is time-consuming and at times quite difficult.

The methods thus far mentioned cannot and do not replace properly performed tonsillectomy. However, for the treatment of tonsillar remains, such as so-called "stumps," electrodesiccation cannot be surpassed. Also, in those cases where surgical removal is refused or contraindicated, the partial destruction of tonsils, performed bloodlessly, is sometimes not without merit and benefit.

We are indebted to Dr. D. Kobak, of Chicago, whose plans we have used, for the construction of an instrument (Fig. 77) which is a modification of the Beck-Shenck tonsillectome. The handle was left unchanged, save that

provision was made for connecting the wire with a diathermy apparatus. The terminal fenestrated shank was made of hard rubber to insure insulation. The fenestrum was fashioned round instead of oval and somewhat larger than the usual Vedder loop.

The technic of operation is as follows: A biterminal D'Arsonval current is used. A sheet of block tin (5″ x 8″) is placed firmly to the abdomen or back and serves as the indifferent electrode. The patient is anesthetized in

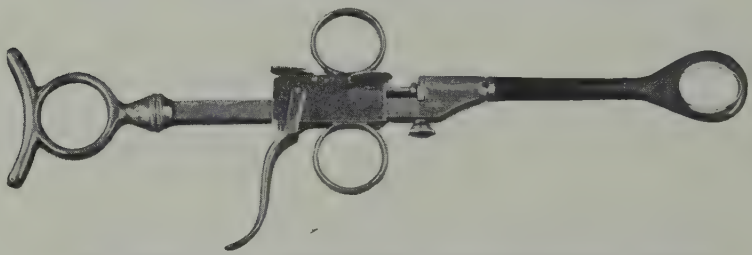

Fig. 77.—Modification of Beck-Schenk tonsillectome with insulated Vedder loop for coagulation-dissection of tonsils.

the customary way. Up to the present all cases have been operated on under general narcosis. During the interval, the instrument is attached to the high-frequency pole of the apparatus, a foot switch is installed for control and the current set for 400-500 milliamperes. The spark gap should be closed and the diathermy apparatus placed at least three to four feet away from the patient. When the patient is anesthetized and the ether has been removed from the room, the operation is begun.

For the right tonsil, the instrument is held in the right hand. The tonsil is first engaged as in the usual Beck operation. This is attained by picking up the inferior and posterior portions of the tonsil with the fenestrated end of the instrument, and pressing the rest of the tonsil

through the fenestrum with the middle or forefinger of the other hand. The wire is now pulled down around the tonsil as far as it will go without forcing, and locked. If the tonsil is properly engaged, a small dimple in the anterior pillar will be seen. An assistant grasps the tonsil with a tenaculum and exerts steady moderate traction anteriorly and medially. The operator supports the instrument in one hand and holds the wire-tightening screw in the other. The foot is placed on the foot-switch. The current is turned on for a half to one second. The hand holding the tightening screw will feel the release of tension, which of course indicates the termination of current. Sparking should be avoided. The wire is tightened again without forcing and the current turned on. The release of tension is again felt. The tightening is repeated and the operation continued. Three or four such phases are necessary for the removal of the tonsil. Bleeding does not occur at all or, occasionally, in a negligible amount when the wire has been forced prior to the turning on of the current.

The left hand holds the instrument in removing the left tonsil and the technic otherwise is identical with that described.

The entire operation should not consume more than a few minutes, thus rendering resumption of the anesthetic unnecessary.

The post-operative course is favorable. Secondary hemorrhage has not occurred. The local reaction is perhaps less than that following a clean tonsillectomy. There are no untoward systemic reactions. Healing occurs in the usual time, leaving softer scars and less distorted looking pillars.

Post-operative care of the throat includes aspirin

gargle, cresatin topically to the tonsillar fossae, and occasionally exposure of the pharynz to the ultraviolet rays.

The following conclusions may be drawn:

1. The method should be undertaken only by one thoroughly familiar with the Beck instrument and technic, as well as surgical dissection of tonsils.
2. The method insures a bloodless removal of tonsils at one sitting without danger of secondary hemorrhage and absorption of toxins by the lymphatics, and without the occurrence of sparking.
3. The depth of the coagulation is minimal and sloughing is therefore negligible.

Diphtheria Carriers.—Ultraviolet light is claimed by Donnelly of Detroit to sterilize tonsils or nasal membranes from this type of infections. His work was carried on in co-operation with the contagious disease division of the Detroit Board of Health. Forty cases made up the first series. Subsequent to treatment cultures were examined and reported upon by the Board of Health Laboratory. Donnelly employed a hollow metal tube applicator six inches long, with the end slanted to fit over the tonsil. The rays were directed on all portions of the tonsil and each tonsil was treated separately.

Further experimental observations showed that while it takes eight minutes at six inches to sterilize cultures contaminated with diphtheria bacilli, using the tonsillar applicator, diphtheria germs in the tonsils were killed through the same applicator in two minutes, the treatment of an individual area usually being three minutes. Diphtheria toxin treated for five minutes with the ultraviolet rays is rendered harmless.

CHAPTER XXII

THE LARYNX

Simple Acute Laryngitis.—Simple acute laryngitis, if uncomplicated by other causes, such as tonsillitis or nasopharyngitis, is relieved by ultraviolet light applied by means of special laryngeal quartz applicators. It is best to have the apparatus suspended on a bracket or stand and the applicator introduced into the pharynx without too much manipulation (Fig. 78). Accurate timing of the treatments is important. Usually one-half minute is the initial dose, gradually increased on successive or alternate days, depending on the tolerance of the patient and the severity of the disease.

Direct diathermy (Fig 79) over the neck muscles sometimes affords great comfort to the patient and may relieve the hoarseness. Vacuum or non-vacuum electrodes (Fig. 80) may also be employed. There is no contraindication to the use of diathermy preliminary to ultraviolet treatment, as occasionally both procedures work out better than either one alone.

Laryngeal Tuberculosis.—Mayer, of Saranac Lake, has recently reported some interesting observations on the action of ultraviolet light on tuberculosis of the mucous membranes. He found that this condition responded to combined local and general body exposures. Mayer thinks that the possibilities of affecting laryngeal tuberculosis with artificial light sources are theoretically promising, since it is possible to provoke chemical changes

in the tissue, focal reactions (as with tuberculin treatment), hyperemia and even destruction of at least the most superficial of the bacteria. He stated further: "It

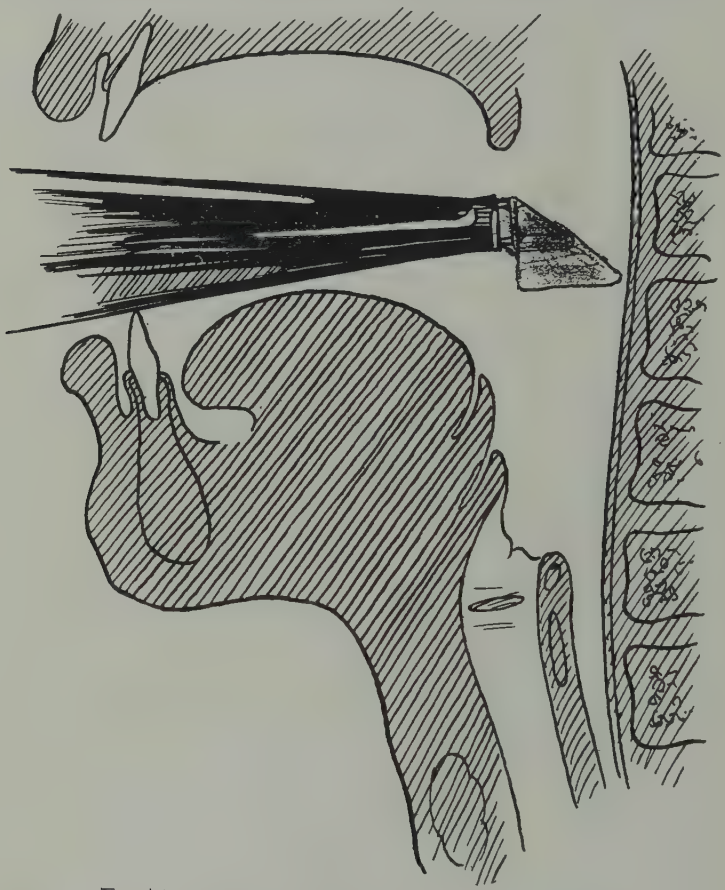

FIG. 78.—Exposure of larynx to ultraviolet light.

seems imperative in all forms of tuberculosis to which light is applied to combine both general and local irradiations. It has been shown that healing takes place in

30 per cent more of cases of lupus vulgaris when general body irradiations are used in addition to local exposures."

FIG. 79.—Direct diathermy to larynx.

A good deal of work in treating tubercular laryngitis with quartz light has been done also at the Glen Lake Sanatorium. The technic employed in this institution

involves the use of the Baldwin laryngoscope. The treatments are given for one minute each day for seven days, during which time the larynx is closely observed. If there is no exaggeration of symptoms, the time of exposure is increased one minute each week until five minutes are reached. If the pain and inflammation increase during the application, the shorter period of treatment is adopted.

Fig. 80.—Diathermy to larynx through vacuum or non-vacuum electrode.

The technic which we employ is very similar. Unfortunately, our experience is limited, because most patients who presented themselves had to be referred for sanatorium treatment on account of pulmonary involvement. We prefer the preliminary sensitizing application of mercurochrome or eosin by means of a spray. It is usually unnecessary to anesthetize the pharynx unless the patient is extremely sensitive. The applications are made locally with a special quartz laryngeal applicator and the water-cooled lamp, followed by general body

exposures with the air-cooled lamp. Needless to say, general measures recognized to-day in the treatment of tuberculosis are essential also with this therapy.

Wessley employs as his light source an arc light, the pure carbon spectrum of which is completed up to the wave length 290 u. u. (2900 A. u.) by adding metallic salts and which, therefore, embraces the entire ultraviolet of high altitude sun. By means of a suitable quartz system the light is made to form a cone. Heat rays are absorbed by an intercepting water jacket.

The light is applied by reflection directly to the diseased part. In place of the customary laryngeal speculum, Wessley employs nickel and steel mirrors giving an equal and economical utilization of light. The mirror is fixed in the patient's mouth by a suitable appliance. Irradiations are given first every other day and later at longer intervals, for seven to ten minutes each sitting. Treatment is continued, according to the nature of the case, for periods varying from a few weeks to one and one-half years.

This same writer believes that local light treatment is successful, not only in localized afebrile cases, but also in extensive processes not suited to other local treatment and further in febrile cases, but only with exact observations of the lungs, temperature, weight, rapidity of sedimentation, and so forth. In cases where the regenerative power has fallen below a certain limit, light will fail to induce reparative processes.

Of 164 cases treated 46 were cured locally, 32 improved, 20 remained uninfluenced, and 24 became worse. In 42 patients treated symptomatically for dysphagia 23 were completely relieved, 11 were improved temporarily and 8 were not influenced.

The technic of Cemach differs somewhat from that of other laryngologists. In patients tolerating quartz light well, this author favors subsequent irradiation with blue light, which is less stimulating and has a better deep effect. For dysphagia only blue light is employed. Curative results by this method are entirely satisfactory. Infiltrates disappear completely and ulcers heal and cicatrize. Severe extensive processes disappear or leave only very slight traces. The effect on dysphagia is striking even in terminal cases. Of 24 cases treated, 17 were cured. The 17 patients were selected from the others by their immunity state, an important factor governing the success of the treatment. At the commencement of, or during treatment, these patients showed marked cutaneous allergy without noteworthy general or focal reactions. Coincidently with phototherapy general treatment was instituted.

According to Danziger, the only explanation for the splendid results claimed by some writers appears to lie in the failure to differentiate between inflammatory conditions complicating tuberculosis of the lung and real tuberculous lesions of the larynx. Laryngeal complications of pulmonary tuberculosis are not all of a tuberculous nature. The same writer asserts that treatment with ultraviolet rays benefits mild cases, but not those with extensive infiltrations and ulcerations.

With reference to the use of other physical agents in laryngeal tuberculosis, one must not overlook the work that has been done with roentgenotherapy. In the progressive exudative ulcerative and productive ulcerative forms of this affection, roentgenotherapy has been unsuccessful, better results having been obtained in the mixed forms, especially when the productive factor predomi-

nates. The other productive forms are the proper field for Roentgen irradiation, if the pulmonary and general condition is good. The best results of roentgenotherapy, according to Anthon and Simons, are recorded in cases of productive tuberculosis of the larynx—in the initial stage or where coexisting pulmonary tuberculosis has passed into the closed form. The combined treatment—a course of four to six Roentgen irradiations followed by a sojourn in a special sanitarium or at a high altitude—has yielded very good results in prognostically favorable laryngeal and pulmonary findings. The effect of roentgenotherapy is obtained very slowly, requiring weeks or months. In severe cases the results are uncertain, necessitating the use of the galvanocautery for isolated infiltrates.

Neuroses of the Larynx.—The laryngologist is not infrequently called upon to manage this ailment. The usual medical measures are of little avail. Electrotherapy, on the other hand, offers much encouragement. Indirect or direct diathermy, ultraviolet light and the interrupted galvanic current, singly or in combinations, are effective aids in the treatment. Successes from the use of the interrupted galvanic current have been reported by several writers.

Tracheitis.—The treatment is similar to that suggested for acute laryngitis. One should endeavor to have the quartz applicator reach into the pharynx as deeply as possible. Diffuse raying of the neck with the air-cooled lamp is also of service and this may be preceded by direct or indirect diathermy.

CHAPTER XXIII

TUMORS OF THE MOUTH, PHARYNX AND LARYNX

General Remarks.—The management of malignant tumors of the mouth, pharynx and larynx has always been a difficult problem, due to the fact that patients usually present themselves at a time when little can be hoped for in the way of a cure. Metastases and glandular involvement are discouraging factors, and in spite of the fact that with modern methods the new growths themselves can be readily destroyed, the prognosis is almost invariably unfavorable. X-ray, radium and surgical diathermy, either singly, or in combinations, are powerful weapons, affording the surgeon a rational treatment. Surgical diathermy, either as electrocoagulation or as electrodesiccation, has made rapid strides in cancer therapy to such an extent that few if any surgeons will deny that the knife has been adequately replaced by physical methods.

Tumors of the Mouth.—Malignant growths of the mouth, and especially the tongue, are easily accessible, and therefore may be attacked with less difficulty than carcinoma of the pharynx or larynx. Reference has already been made to the use of radium needles as advocated by Simpson and others. The X-rays also have been employed for some time, but better results have been reported from the use of surgical diathermy, reserving radiation as a follow-up treatment. While the technic for electrocoagulation and electrodesiccation has been

described in the chapter dealing with tumors of the nose, several additional interesting and important points are given in the section on *tumors of the larynx.*

Tumors of the Pharynx.—D. M'Kenzie advocated diathermy in the treatment of both eradicable and ineradicable pharyngeal cancer. Its value lies in its double action of cauterizing and coagulating the diseased tissues, with a sterilizing effect upon the surrounding tissues. In dealing with a limited cancer, the primary deposit should be removed by diathermy, and the lymphatic glands by dissection and diathermy, the intervening tissues being treated by diathermy puncture. While this can be done at one sitting M'Kenzie thinks it is better to divide it into two separate operations. In ineradicable conditions, bold and wide diathermy of tissue will prolong life, and the glands after diathermy puncture may shrivel and disappear. While diathermy may, like other therapeutic, measures enhance malignant growth, the fact that its action is both destructive and actively germicidal renders such a result less likely than with other methods.

We have not employed dissection of the lymphatic glands as suggested by M'Kenzie, nor are we familiar with such practice in this country. Dependence for control of glandular involvement is usually placed on the X-rays, and, while they are not always adequate, good results have occasionally been recorded. There is little doubt that dissection combined with diathermy is a sound procedure, overcoming the objections of those who are opposed to sharp dissection in malignant metastatic growths.

Patterson has found diathermocoagulation superior to surgical methods and prognosticates good results in the

early stages of cancer before the glands are involved. Ligation of the arteries supplying the tumor and removal of the cervical glands are considered important measures. Patterson, as many others, is opposed to excision of a growth even if only for diagnostic purposes, as the tumor is frequently stimulated and its development hastened. Eighteen cases reported by him included cancer of the tongue, the palate, the posterior wall of the pharynx, the tonsils, the anterior pillars, and the floor of the mouth. In this series cures were effected with no recurrences during a period of observation ranging from one and one-half to eight years. Some of these cases had been rejected as inoperable. One patient, who had been successfully treated for a small tumor of the uvula, refused surgical extirpation of the cervical glands. Four years later the cancer developed in these glands, whereas there was no recurrence in the uvula or in the palatine region.

Tumors of the Larynx.—Novak, who has had a large experience in the treatment of cancers of the pharynx and larynx with surgical diathermy, lays much emphasis on the choice of the anesthetic. He holds that local or block anesthesia cannot be recommended. The danger of ignition from an accidental spark makes ether an utterly impossible agent. The narcosis from nitrous oxide is not sufficiently even to make it consistently available in this work. If nitrous oxide is selected, it must be administered by an expert. Chloroform has proven the most satisfactory anesthetic despite its reputed dangers which, as a matter of fact, in a large measure can be averted by careful administration.

The oro-pharynx is easily accessible, but the approach to the larynx is a difficult problem. For the decision between operating under suspension laryngoscopy or

through a laryngofissure, the location of a neoplasm is of considerable importance. If the mass is extensive and situated largely in the sub-glottic space, it is better to operate through a laryngofissure; in the case of a small tumor limited to one vocal cord, and located on the under surface of the cord, it is also better to operate by thyrotomy. Malignant disease of the larynx, which shows peri-laryngeal lymphatic involvement, is better approached by thyrotomy than by suspension laryngoscopy, inasmuch as surgical removal of the glands is necessary and may be done by extension of the incision for laryngofissure.

Suspension laryngoscopy is, therefore, particularly suitable for malignancies even of large size situated in the upper portion of the larynx in the earlier stages of development, when invasion of the extra laryngeal tissue is not manifest.

It has been Novak's practice to employ diathermy in the treatment of malignant new growths of the larynx, approaching the mass under the guidance of suspension laryngoscopy in all cases except those for which this method is contraindicated. Suspension laryngoscopy has been used by many for the surgical removal of various growths in the larynx, and diathermy has been employed in the treatment of benign growths; a careful search through the literature has, however, shown that very little has been reported regarding the treatment of carcinoma of the larynx by electrocoagulation under suspension laryngoscopy. Dutheillet de Lamothe has reported one case of supposed carcinoma of the larynx which was operated by electrocoagulation under suspension laryngoscopy. Biopsy revealed that it was a case of tuberculosis.

Electrocoagulation under suspension laryngoscopy is particularly adapted to the following types of cases:

1. When the tumer is located largely above the glottis;
2. When there is no extra-laryngeal lymphatic involvement;
3. In patients most favorably suited to suspension laryngoscopy, *i. e.*, with long thin necks, thin mouth and tongue, good teeth and normal epiglottis.

Technic.—With the interior of the larynx exposed, either by laryngofissure or suspension laryngoscopy (Fig. 81), the technic of diathermy is much the same. Con-

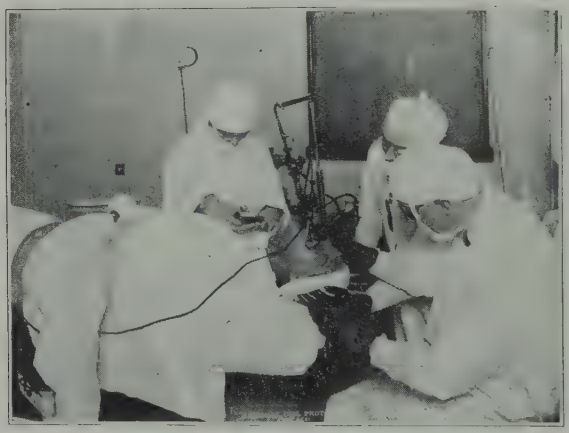

FIG. 81.—Electrocoagulation of carcinoma of the larynx under suspension laryngoscopy.

siderable discussion has arisen concerning the best electrodes for the diathermy of tumor masses, that is to say, whether the electrode in contact with the mass should be of the disc or needle type. For small tumor masses the needle electrode is preferable; but in dealing with a large tumor mass there are certain objections to the needle method. The tendency of the high frequency current is to leap from a point as a spark. Therapeutically,

sparking is undesirable, for a spark has the tendency to desiccate the tissue in its immediate vicinity. A gaseous pocket is formed in the tissue, the walls of which become rapidly carbonized. This carbon layer is a veritable insulator to the current and thereby deep penetration of heat into the tissue is greatly interfered with. In the needle procedure, it is necessary to make many punctures, and even then the much desired heat penetration effect is imperfect. The use of a button or ball electrode applied to the surface of the growth is much preferable. Although penetration of heat through the tumor is slower, it is more thorough and more homogeneous than with the needle, to say nothing of the absence of surface carbonization. The rapid desiccation and carbonization of the tumor is an avoidable accident, the result of faulty technics.

The amount of current necessary, in a large measure depends upon the size and consistency of the tumor as well as upon the size of the electrode. It is difficult to formulate a table of dosage, but as a general rule the following may be suggested: the smaller the electrode, the less current should be used; the greater the consistency of the mass, the less current is necessary. The rationale of these general rules is obvious because they are based on the fundamental principles of electrocoagulation.

The average amount of current usually employed is from 1200 to 1500 milliamperes (D'Arsonval). The average electrode used is one centimeter in diameter and the average time of exposure is twenty seconds. The electrode is applied successively to different areas of the tumor surface, and the successive layers of coagulum are removed with the curette.

Some Effects of Surgical Diathermy with Special Reference to the Larynx.—It is scarcely necessary to emphasize what the usual effects of diathermy are on the tissues when coagulation takes place, as these have already been recited elsewhere. Certain factors with special reference to the larynx are important. First, there is the element of pain. Some patients with laryngal carcinoma complain of this symptom. Others, with even well-advanced growths, appear to be fairly comfortable. As a general rule patients complain less of pain after coagulation than before, though in some cases the pain may be greatly increased.

Secondly, damage may be done to the important vessels and nerves in this region. Such an objection is valid; and, viewing the anatomical relations of the larynx to the important adjacent structures, it is important to know the possibility of damage to the vagus, the carotid, or to the internal jugular, during the process of electrocoagulation of a large tumor of the larynx.

From Novak's clinical experience with laryngeal tumors in which diathermy was employed, there was no evidence of any damage to the structure referred to. In order, however, to obtain more definite information in regard to such possible damage, and to verify the clinical findings, some experimental investigations were made on dogs. The larynx was opened and its interior subjected to a degree of heat much in excess of that ever used in the coagulation of a tumor in the human larynx. An electrode was placed against the ala of the thyroid cartilage successively in different areas and a current of 1500 to 2000 milliamperes applied for a period of from 30 to 60 seconds. After killing the dog, the tissues of the neck, including the contents of the carotid sheath,

were studied. It was found that none of the layers of the carotid nor of the internal jugular showed any changes whatever. The lumina of these vessels showed no thrombosis. Neither was any change observed in the vagus nerve. From this brief statement it can readily be seen that the amount of current (and, consequently, heat) necessary to coagulate a neoplasm in the region of the larynx is insufficient to damage in any way the important structures lying in the immediate vicinity of the larynx.

Conclusions.

1. The larynx is best approached either by suspension laryngoscopy or laryngofissure, and the choice rests entirely with the surgeon, who must pass on the requirements of each individual case.
2. Chloroform is the ideal general anesthetic, but must be administered by one thoroughly skilled in this form of narcosis.
3. A preliminary tracheotomy is imperative in all cases.
4. Diathermy offers many advantages over surgery; diathermy plus radiation is superior to diathermy or radiation alone.
5. The superiority of diathermy over other methods employed for malignant laryngeal tumors, can be determined by extensive trials.

Results Obtained in the Treatment of Cancer of the Larynx with the Roentgen Rays.—Coutard and Hautant have treated twelve patients by this method. They concluded that the results obtained were not uniform. Those reported by German operators are especially discouraging. In the first series of six cases, only one fatal result has occurred, after a period of two years, the mortality being 17 per cent. In the second series of six cases, death occurred in two cases, within three months after the termination of treatment, the mortality being 33 per

cent. No late recurrences have supervened. The total mortality was 25 per cent. Seven of the twelve cases appear to be permanently cured, the rate of success being 58 per cent. In two cases, thyrotomy and partial ablation of suspected tissues supplemented the Roentgen treatment.

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PART SIX

BORDER LINE DISEASES

CHAPTER XXIV

SOME METABOLIC AND ENDOCRINE ASPECTS OF EYE, EAR AND NASAL DISEASES

The recognition of the simple but essential fact that many nasal affections are merely local manifestations of certain systemic disturbances shows the utter fallacy of relying on topical treatment alone.

It is but recently that rhinologists have familiarized themselves with endocrinology, and as they studied the influence of the ductless glands on nasal affections, their therapeutic results became better as a consequence.

Beck, some time ago, called attention to the following diseases in connection with disorders of the ductless glands:

1. Atrophic rhinitis.
2. Hyperplastic or non-suppurative sinusitis in which we have:
   a. Hay fever.
   b. Hyperesthetic rhinitis with or without hydrorrhea.
   c. Asthma.
3. Septal deflections and excrescences.
4. Otosclerosis.
5. Exophthalmic goitre.
6. Status thymico-lymphaticus.
7. Myxedema.
8. Epilepsy.
9. Acromegaly.
10. Fröhlich's syndrome.

The above classification is of general interest because it shows the extensive relation of the ductless glands to

a variety of clinical entities, but the factor which concerns us particularly is to be sought in the adrenals, the hypophysis and thymus glands.

Beck concludes that the pathological changes in the bony capsule of the labyrinth in otosclerosis are analogous to the changes in osteomalacia and, to a certain degree, in the turbinated structures in the above-mentioned diseases. The same applies also to the bony changes of the septum at the point of deflection and ridge formation.

Basal Metabolism.—The ophthalmologist and otorhinologist will find the modern methods of calculating the basal metabolic rate of great assistance to them in hyperesthetic rhinitis, seasonal hay fever, asthma, sinus diseases and many eye affections of undetermined origin.

The basal metabolic rate is one of the means of clearing up an otherwise obscure etiology.

Basal Metabolic Rate in Hyperesthetic Rhinitis.—Novak, in 1921, measured the basal metabolic rate in hyperesthetic rhinitis in a series of cases and found the metabolic index low. Simpson similarly studied this problem, but found a low metabolic index in an exceedingly small number of cases. Beck later confirmed that the index was low in most instances.

We have studied this problem in a series of 100 cases and observed that the metabolic index was normal, low normal or definitely low in 65 cases of the series.

The differences of opinion and findings may, doubtless, be explained by the circumstance that there has not been a standard for calculating the metabolic rate, so that the diverse computations were not uniformly interpreted.

Calcium Metabolism.—The relation of the calcium content of the blood to some nasal diseases has been

recently advanced by several investigators. The solution of the problem of measuring the calcium content of the blood serum in a variety of pathological conditions was undertaken by Halverson, Mohler and Bergeim in 1917. Kramer and Tisdall, in 1921, showed how calcium determinations could be made not only in small amounts of serum but also in plasma. Calcium is said to be present in the blood in two forms, ionized and combined. When coagulation of the blood occurs, the calcium in the exuded serum is found to have the ionized form. Grove and Vines accepted as normal 10.5 mg. per hundred c. c. of blood serum, while Halverson, Mohler and Bergeim accept 10.2 as the standard. More recently, however, the conclusion has been reached that blood calcium deficit of some nasal and so-called border line diseases is in no way indicative of the severity of the symptoms; in other words, *that the blood calcium standard is an individual phenomenon rather than an arbitrarily accepted figure.*

Calcium Metabolism in Otosclerosis.—Hans Leicher of Berlin reported a decrease in blood calcium in about 75 per cent of cases of otosclerosis, while in cases with apparently normal calcium values, disturbances in calcium metabolism could nevertheless be assumed. The question arose as to what other clinical symptoms could be caused by the decreased calcium content of the serum in otosclerosis, and what the causal connection was between calcium deficit and endocrine disturbances. Leicher cites the fact that in patients with apparently normal calcium values, a lability in calcium metabolism could be demonstrated therapeutically. This would seem to answer the question frequently asked, why calcium or calcium influencing agents should be administered in some diseases when the calcium content of the blood by determination is apparently normal. *The calcium metab-*

olism may be disturbed, and yet this fact may not be demonstrable by present laboratory methods. The final test is the therapeutic one—at least at present—until more adequate and exact means of measuring the blood calcium shall become available.

Leicher observed that during pregnancy and the puerperium, only a small number of cases showed a diminished calcium titer, though the diminution was very definite. He concluded that in pathologic cases a diminution of the calcium titer of the blood may easily occur during pregnancy, a contention that is in accord with the clinical observation that diseases accompanied by a decrease of calcium in the serum are often, or nearly always, made worse by pregnancy, or originate only during pregnancy. If a calcium factor exists in otosclerosis, it is quite evident that it is of considerable importance, not only for the diagnosis, but for the treatment of this disease.

Leicher also pointed out that in considering the possibility of successfully treating blood calcium deficit, a distinction must be made between patients in whom only the *total* calcium (or combined calcium) of the serum is decreased, and those with positive signs of a deficit in *ionized* calcium. For treatment he recommends cod liver oil, parathyroid extract, or the administration of calcium, orally or intravenously, in combination with ammonium chlorid.

While Leicher's treatment is valuable, we possess in the mercury vapor quartz or arc lamps therapeutic agents which, unquestionably, have a more rapid and pronounced effect on calcium deficiency diseases.

Endocrine Dysfunction as a Possible Etiologic Factor in Progressive Deafness.—Drury studied progressive

deafness to determine the influence of endocrine factors. His views and conclusions are:

In otosclerosis the absorption of any portion of the margin of the oval window might interfere with the nutrient supply of the contiguous part of the annular ligament of the stapes. This might engender an absorption of the ligament itself, which, in turn, could become more compact in structure. Endocrinic influence might well initiate, supplement, or modify such changes. The criteria for the selection of the cases studied were loss of hearing by air conduction for a considerable part of the lower end of the tone series, prolongation of bone conduction above normal, negative Rinné test, presence of tinnitus, vertigo or paracusis Willisi, practically normal drum membranes, patent Eustachian tubes and a reddish blush seen through the drum behind the umbo. A large number of vital function tests from various sources were studied with normal human subjects and their significance evaluated. A group of cases which presented demonstrable endocrine defect limited to a single focus were next subjected to the same methods of study; in this way both the sense and amount of deviation caused by aberrant function could be determined. Finally, individuals of unrecognized etiology were selected, a diagnosis established by conformity of their tests to one of the conditions previously studied, the indicated specific glandular substance administered as medication, and the effect determined by repetition of clinical and laboratory studies.

In the series studied, the aberrant endocrine function indicated a lowered rather than an increased activity. Several individual foci were implicated, as the pituitary, the thyroid and the ovary. No so-called pluriglandular

cases were observed. No specific adrenal influence was recognized, nor did the testicle seem to be a factor. In no case was concomitant bone disease observed. Otosclerosis would seem to be the result of several divergent and apparently unrelated causes. The definite percentage of non-endocrine cases shows the uselessness of promiscuous glandular medication.

Calcium Metabolism in the Hyperesthetic Nasal Diseases.—Even in the presence of accepted normal calcium findings, disturbances in calcium metabolism exist in hyperesthetic rhinitis, seasonal hay-fever, and asthma. For, as Leicher has shown, disturbances of calcium metabolism are not always demonstrable by our present methods of blood calcium determination. Furthermore, etiologic factors other than a calcium deficiency must be borne in mind in hyperesthetic diseases of the upper respiratory tract.

To prevent misunderstandings which have become apparent in the contemporary literature, it is emphasized that disturbed calcium metabolism is not the sole causative factor in hay fever and asthma. Calcium metabolism has been especially stressed because it appears to play an important rôle in the hyperesthetic diseases. Calcium, as a mineral salt constituent of the blood, can be measured and therefore made a subject of careful observation.

TABLE OF CALCIUM DETERMINATIONS

	Number of Cases	Lowest Calcium Finding	Highest Calcium Finding	Average For Total Cases
Perennial Hay Fever (Hyperesthetic or Vasomotor Rhinitis)	112	6.76	10.2	8.6
Seasonal Hay Fever (All Types)	142	8.7	11.2	10.47
Bronchial Asthma	59	8.0	10.5	9.1

Bowler and Walters have shown that a deficiency of blood calcium may exist and yet not be demonstrable by any known tests. It requires approximately double the amount of injected calcium to raise the blood serum calcium content of the jaundiced dog to the level of the normal dog, in spite of the fact that the blood calcium content is practically the same before and after injection of the lethal dose, suggesting a calcium deficiency in the jaundiced animal which is not apparent in the blood serum calcium taken before the injection. This is borne out by the observation that although the lethal dose is larger in the jaundiced animal, the blood serum calcium contents taken at death are within a reasonable range of equality.

Calcium: Various Preparations and Methods of Administration.—Calcium may be administered orally, intramuscularly, or intravenously. The lactate and the chloride of calcium are commonly prescribed for oral use. Chloride of calcium is also put up in five and ten per cent solutions for intravenous therapy. We have never favored the intramuscular route and we know of no reason for its employment.

To obtain permanent effects, the administration of calcium must be continued for a long period. Schlossman recommends the use of a table containing 1 gm. of calcium citrate mixed with chocolate. In this form several grams of calcium may be given daily without inconvenience. For children, the tablet is dissolved in milk. Schlossman believes that the effect of calcium citrate on the calcium content of the blood serum is not only virtually equal with that of calcium chloride, but has the advantage of an alkalinizing effect on the body fluids as

compared with the prolonged administration of calcium chloride, which produces acidity.

Parathyroid extract is said to regulate calcium metabolism, but the inertness of the preparations now on the market mitigates against it. The ideal method would be parathyroid transplantation. Experience has taught that a preparation of thyroid with parathyroid and some calcium salt, combined with systemic ultraviolet radiations, is by far the most powerful agent to augment the calcium content of the blood serum.

Pituitary Function and Diseases of the Accessory Sinuses.—Numerous case reports have appeared in the literature showing that pituitary function is sometimes disturbed by sinus disease. While the gland is so located in relation to the skull that it is well protected against trauma and infection, involvement due to abscess formation in the sinuses, especially the sphenoid, is likely to occur. Such pathology is not common, and consequently is not usually looked for or even considered. The diagnosis, it may be added, is fraught with exceedingly great difficulties.

With disturbed pituitary function, general metabolic factors become recognizable. Infection, if it exists, may be of low grade and chronic in character. If the diagnosis is made early enough and drainage of the offending sinus is improved, the gland may resume normal activity. General improvement is readily apparent when this has taken place.

The pituitary gland is not infrequently the cause of metabolic manifestations typically characteristic of general systemic disease, as well as of nasal phenomena. The endocrine chain is incomplete without a consideration of the pituitary gland. Its peculiar position, its

relation to the other organs of the head and brain cavity, and its possible direct or indirect influence on some eye and nose conditions, dictate a thorough understanding of its anatomy and physiology, especially since authoritative information on this subject is still limited.

Disorders of the Pituitary Gland and Their Relation to Some Eye Diseases.—Blindness of pituitary origin is comparatively rare. Kern, who reported a case, believes that this is so simply because the disease is not usually recognized. His patient complained of severe headaches and total loss of vision in the left eye, with which he could poorly distinguish between light and darkness. The headaches dated back about two years, at a time when he was discharged from military service. He was operated upon for ulcer of the stomach, but with no relief. Lues and other organic infections were ruled out. Eye examination showed a retrobulbar neuritis of the left eye and also a temporal hemianopsia. Field examination of the right eye was not possible, on account of absence of vision. The X-ray findings were suggestive of a pathologic pituitary body. Glandular medication was prescribed and improvement of vision was noted shortly thereafter.

The patient made considerable progress, which doubtless would have been more pronounced had a correct diagnosis been made earlier.

Laws reported a case of a rare form of retinochoroiditis, which he thought was associated with pituitary dysfunction. A girl of 20 years had noticed dimness of vision in the left eye. Ophthalmoscopic examination showed a hazy disc, with retinal edema. No choroidal lesions were visible at the time, but they soon began to appear and five months after the first visit the eye showed an exten-

sive area covered by patches of superficial choroidoretinitis. Three years after the first onset the right eye began to show retinal haze and misty vision, and it went through an attack exactly like that of the left eye. When the patient was last seen, the right vision was 6/5, partly, left 6/5, nearly. The fundi had the appearance of a case of old specific choroidoretinitis, except that the optic disks showed no pallor and the retinal vessels no narrowing. The patient was a healthy-looking girl, with a good family history and good habits. Careful examination by a consulting physician revealed no sign of disease; Wassermann and tuberculin tests gave negative results. This and other somewhat similar cases seem to indicate that disturbance of pituitary function is a possible cause of well-marked retinochoroidal inflammation. Laws suggests that in the absence of any other obvious causative agent the form of retinochoroiditis in the case described may be the result of a transitory pituitary dysfunction, which seems to occur in adolescents, characterized by an acute onset, with much inflammatory change in the optic nerve head and retina, to be widespread, but always superficial, with a self-limited course and recovery with relatively good vision.

Organotherapy in Disease of the Ear, Nose and Throat.—Thyroid enlargement in cases of nasal and aural suppuration has been observed by Leighton. He advocates small doses of thyroid extract to supply the increased secretion required by the body for the combating of the sepsis. The gonads bear a part in the etiology of the various neuroses which are as yet imperfectly differentiated, but which are included under the headings of neuroses, psychoses, psychoneuroses, hysterias, and neurasthenias. It is advisable, therefore, to investigate

the organs of internal secretion in cases of hysterical deafness, functional aphonia and paresthesia of the pharynx, and to treat the patients according to the findings. One should always be on the lookout for cretinism in deaf mutes. Scholtz states that 30 per cent of the endemic cretins seen by him were so afflicted. Besides such cases of advanced hypothyroidism, ear symptoms are frequently observed, especially tinnitus, in the minor grades. The author (Leighton) has prescribed mammary gland, ovarian extract and adrenal gland with very favorable results. (Leighton.)

CHAPTER XXV

HEADACHE—TRIFACIAL NEURALGIA—FACIAL PARALYSIS

General Remarks.—We are especially interested in the so-called reflex headache, a type which is usually attributable to ocular disturbances, sinus disease, or imperfect ventilation of the nose. Refractive errors are the most common of the ocular causes. So-called idiopathic headache, or migraine, has been and still is an unsolved problem, but some new facts have recently been brought to light which should prove of considerable interest. The specialist is particularly concerned with "sinus headache," "ocular headache," and that type of headache produced by intranasal defects.

Headache Due to Sinus Disease.—Probably no complaint is so intense as that coming from a patient who suffers from headache due to acute infection of the nasal accessory sinuses. In chronic cases, the head pains are also present, but they are described by the patient as a "dull ache." It is useless to employ electrotherapeutic methods in chronic affections of this type, unless the underlying pathology has first been corrected. The symptoms may be relieved, but cures are to be promised with reservations. For sinus disease, the Dowling method of argyrol tamponage should be instituted and treatments given daily. Suction and other routine measures are essential and should be carried out. Intranasal ultraviolet radiation and diathermy are valuable local

adjuvants, and should be supplemented by general body irradiations with the air-cooled quartz lamp. If the headaches prove refractory to these measures, diathermy direct to the offending sinuses and the head is the appropriate treatment.

Headache and Intranasal Deformities.—Septal deviations and septal spurs are known to cause chronic headaches. The general practitioner as a rule is reluctant to accept as a cause any intranasal deformity until his therapeutic armamentarium has been vainly exhausted. Needless to say, the radical measure which cures is surgery. The submucous resection of the nasal septum is to-day a perfected and safe operation. The limitations for its performance are age of the patient, general health, and serious organic disease. The operation should not be done on children or young adults unless positively indicated. Following septal resection, healing and postoperative convalescence can be materially aided by the use of argyrol tamponage and local general quartz light exposures.

Recent literature is replete with dissertations on headaches of intranasal origin. Sluder's monograph on this subject contains much enlightening information. One of the more recent contributions is that of Laugier, who in four months observed 14 cases of intense headache of intranasal origin, all of which were cured by proper surgical intervention. In no case were there any nasal symptoms to suggest to the patient that his trouble was of this nature. These agonizing headaches of the type under discussion are due either to (1) closure of the frontal sinus, without suppuration, (2) the syndrome of neurosis of Meckel's ganglion, or (3) ethmoiditis and hyperplastic sphenoiditis. Eight of the author's cases

belong to the first group, one to the second, and five to the third. In the first group, five of the eight patients had deviations of the septum or hypertrophy of the middle turbinates, sufficient to make pressure and to close the frontal sinus to the entrance and exit of air. All were cured by complete submucous resection of the septum and turbinates, under local anesthesia. The sole case of neurosis of Meckel's ganglion yielded to treatment of the spheno-maxillary region with cocain-adrenalin and by the local application of 2 per cent silver nitrate. In the third group the headache was localized in the frontotemporal region, sometimes extending to the occiput, with vision affected only when the sphenoid cells were involved. Intranasal examination showed strong vascularization of the middle turbinates, and when these were resected it was possible to see how their mucosa had invaded the ethmoid labyrinth. Their resection, with that of the ethmoid cells, followed by prolonged and systematic medical treatment, resulted in complete cure.

Migraine.—Often termed "idiopathic headache" and attributed to functional causes, migraine remains one of the unsolved problems in medicine. Basstrup has reported experiences which justify tentative calcium treatment in all cases of obstinate headache for which the cause is obscure. Migraine always suggests a familial predisposition and the history will usually support such belief, but whatever theories have been advanced the fact remains that this condition is a difficult one to manage. With the therapeutic success attributed to calcium by Basstrup and others, the possibility of metabolic errors is not to be disregarded, especially with reference to the chemical constituents of the blood. General body ultraviolet irradiations appear to be a rational procedure

and should be carried out systematically and persistently. While some experimental work has been conducted along these lines, a conclusive report is not yet available. The appropriateness of high-frequency currents for their effects in ameliorating the distressing symptoms and giving temporary relief is, however, well established. The administration of calcium is indicated empirically, and endocrine therapy may augment the results. In any event, electrotherapy does not conflict with any other method of treatment and should be given a thorough trial.

The pathogensis and therapy of migraine was recently considered at length by Kammerer. The use of electric light is mentioned only briefly by this author. A nonspecific desensitization as an indication for the use of peptone injections is also discussed.

Bigland has used calcium lactate in migraine with favorable results. Thirty grains of calcium lactate are administered at the first sign of an attack. The claim is made that calcium therapy aborts the attack and in many cases prevents the appearance of the headache and the symptoms which accompany it.

The impressions gathered from the effect of calcium in migraine tend to stimulate exact investigation. There, undoubtedly, must be some metabolic dysfunction, probably endocrinic in character, or some other factor producing imbalance of the blood chemistry, with reference to mineral salt constituents. It is appreciated that these are mere conjectures, but they seem plausible in the light of our present knowledge. Ultraviolet light may be a valuable agent in the treatment of this "essential" symptom. At present, however, the good results so far reported must be classified on a basis of empiricism.

While the ability to augment the calcium content of the blood serum by general quartz ray exposures can no longer be questioned, it must be remembered that migraine has not yet been conclusively shown to be a calcium deficiency disease.

Trifacial Neuralgia.—This condition properly comes within the classification of diseases of the nervous system. While this subject is beyond the scope of this book, the specialist is frequently called upon to treat patients with this affection, and a few suggestions may, therefore, prove useful. The pathology of trifacial neuralgia is not known, and an accurate diagnosis may very often be difficult.

Classic methods of treatment have been unsatisfactory. Some relief may be obtained by radaint heat-light and diathermy. The latter should be applied directly over the nerve by means of a head band and special electrode. While we have depended upon diathermy alone, the static effluve has been suggested by some authorities as an additional measure.

Facial Paralysis.—The otolaryngologist encounters facial paralysis following some operations on the head or neck, especially radical mastoidectomy. Return of function may occur without any treatment at all, but when it does not, electrotherapeutic measures are indicated, but must be applied early.

Mild diathermy should be applied for a short time *directly*. If not tolerated with comfort, the indirect method or radiant heat-light should be tried. Later, administration of the slow sinusoidal current is useful. Gentle massage, manually, is also indicated, but the surgeon must determine the most opportune time for this therapy. Recovery of the function of the nerve and

muscles to an extent exceeding seventy per cent is not uncommon.

Elsom pointed out that the prognosis, as in other nerve disorders, is largely based upon electrical reactions. If reaction is normal or nearly so, the prognosis for a fairly early recovery is good. If the reaction of degeneration is only partial, recovery may be expected within perhaps three months; complete reaction of degeneration gives a doubtful prognosis. Recovery may require six months to a year.

Elsom recently discussed the treatment of Bell's palsy. He recommends heat to the affected parts of the face, ear and mastoid region. Its effect seems very beneficial. The heat may be employed in several ways. Hot water bags used at home are helpful.

The application of radiant heat-light from the modern "deep therapy" lamps is our own routine treatment. This radiant heat is followed by diathermy, with the following technic: two metal electrodes are connected to the D'Arsonval terminals of any good, resonant high-frequency machine. The patient is seated near a table, with his elbows resting comfortably. He holds in his hands two hand electrodes, one placed over the affected part of the face near the angle of the jaw, the other on a similar part of the unaffected side. The current is turned on slowly and a few minutes are utilized in gradually advancing the milliamperage to 500. The sensation is one of pleasant, sedative heat. The treatment should last twenty minutes to half an hour. It is better, occasionally, to shift the position of the electrode on the affected side, and for part of the treatment, to apply it near the mastoid region. The next step is the application of the galvanic, slow sinusoidal current. The heat

and the electric treatment are begun at once, allowing no interval from the outset of symptoms.

The galvanic slow sinusoidal current is given by two electrodes of equal size (about an inch and a half in diameter); one of these placed in front of the ear, or on the mastoid region, the other moved about along the motor points of the affected muscles. These are best located near the angle of the mouth, the lower and outer border of the nose and the side of the chin. A mild current is administered especially in recent cases, and continued for only a minute or two; just enough to produce a mild muscle contraction. Later, the stimulation may be increased, and the time of treatment lengthened to five to ten minutes.

In addition, exercise and massage are employed. The patient is encouraged to make efforts to use the affected muscles. Blowing up the cheeks, and trying to prevent the escape of air from the affected side of the mouth is a good form of exercise. (Elsom.)

Elsom's plan of treatment can be improved upon in the method of applying the diathermy. We prefer its administration with the aid of our head band and special metal electrodes. Figures 17 and 67 show the facility with which the treatment is given. The technic is similar to that suggested in the application of the head band and electrodes for impaired hearing, differing only in the position of the active electrode. The indifferent electrode may be placed on the opposite side of the face or on the back of the neck.

Diathermy to the Head.—The older methods of applying diathermy to the head were not only inadequate, but time consuming. With the new head band, the procedure is greatly simplified. The frequency of the treatments

depends largely on the severity of the symptoms. The bones of the skull present some obstacle to diathermizing the head, and it is therefore interesting to know just how the heat is conducted, whether along the bones or through them. That an actual rise in temperature is produced in the brain substance has been proved experimentally, as described elsewhere in this volume. We have never had to contend with dizziness or nausea when applying diathermy to the head, and, in fact, have observed no untoward symptoms of any kind. The current must be gaged carefully and increased gradually. Daily applications are advised.

Grover recommends, regardless of blood pressure findings, eliminative doses of autocondensation, daily, over an extended period.

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CHAPTER XXVI

HYPERESTHETIC RHINITIS (PERENNIAL HAY FEVER)

Hyperesthetic rhinitis or perennial hay fever presents to the clinician greater difficulties than virtually any other malady in the specialty of otolaryngology, with the possible exceptions of cancer and tuberculosis. While hyperethetic rhinitis is not a life-taking ailment, it is responsible for constant discomfort to the patient.

Persons afflicted with perennial hay fever, a term synonomous with hyperesthetic rhinitis, rhinorrhea or nasal hydorrhea, are not dependent upon seasons for the onset of symptoms, and consequently are subject to incessant suffering and are relieved only during certain intervals. These patients are unfit for their occupations for long periods and lose almost complete interest in life. Many are despondent when the symptoms are pronounced and lack ambition to carry on their routine duties.

The tendency on the part of some specialists to administer too much *local* treatment and to disregard the systemic or metabolic aspects of this malady is responsible for many therapeutic failures. Hyperesthetic rhinitis undoubtedly has local etiologic factors, such as poor ventilation or drainage of the nose and accessory sinuses, due to mechanical obstruction or intranasal infection, but the true underlying basis is a metabolic dysfunction. This has been proved by the fact that correction of the metabolic error without any alteration of the local

pathology, sufficed to render the affection free from the distressing symptoms.

Symptoms.—No two text books are in accord on all the symptoms of hyperesthetic rhinitis, but some classical symptoms to designate the disease are considered fundamental by many authors. On examination between attacks the nose appears to be normal except for the anemic pallor of the mucosa. During the attack and for a variable length of time afterward, the turbinates and the mucous membrane lining the septum are waterlogged. The tissues are distinctly pale, soft and swollen. The thin, serous discharge gives them a shiny appearance.

Calcium Deficiency.—Measurement of the basal metabolic rate first suggested the causal relation of metabolic dysfunction. Novak's work on this problem has been described elsewhere. Novak was able to relieve for quite a period of time nearly all the symptoms of hyperesthetic rhinitis by the administration of thyroid extract in comparatively small doses. Subsequent investigations of the blood chemistry by Novak and Hollender gave evidence that hyperesthetic rhinitis is a calcium deficiency disease, the calcium deficit having been demonstrated by laboratory methods. The calcium content of the blood serum was measured, in a series of cases, by many different methods, although the technic of Kramer and Tisdall is now employed almost exclusively. The standard was tentatively accepted as 10.5 mg. per hundred c.c. of blood serum. Figures obtained in hyperesthetic rhinitis ranged from 6.76 mg. per 100 c.c. of blood serum to the approach of the accepted normal (see table on page 244).

Subsequent investigations not only have confirmed this earlier work, but have added proof for the contention

that hyperesthetic rhinitis invariably shows a relatively low blood calcium content. It should be noted, however, that this applies to hyperesthetic rhinitis only, and not to seasonal hay fever or asthma.

Brown and Hunter recently reported their findings with reference to the calcium content of the blood serum in perennial hay fever. Of 43 patients with this disease 37 per cent had definite calcium deficiency, 21 per cent were *low normal,* and 42 per cent were *normal.* These investigators stated further: "Thus our findings in hyperesthetic rhinitis are a sort of happy medium between Novak and Hollender's and those of Sonnenschein and Perlman.[1] The former investigators found that all of their cases of hyperesthetic rhinitis had a calcium deficiency, whereas the latter found that none of their cases were calcium deficient. We believe that these differences are chiefly due to variations in laboratory technic and failure to establish a definite norm for the individual technic."

Parathyroids and Their Action.—It is generally agreed that the parathyroids are regulators of calcium metabolism. The proof of this contention is, however, only therapeutic. Additional proofs have been advanced from time to time by Dragstedt, Luckhardt, Salveson and others. Most of the work has been based on animal experimentation and many things have to be considered in connection with the findings, especially in regard to their clinical application. Salveson discovered in his experiments on the chemistry of parathyroid insufficiency

[1] J. A. M. A. 83:1973-1976, Dec. 20, 1924. These authors noted no calcium deficiency in hyperesthetic rhinitis, but were able to relieve many of their cases by the use of calcium lactate and thyroid. Intravenous injections of calcium caused rapid improvement, due, they believe, to a sedative action.

a drop in blood calcium, which becomes more marked as more parathyroid tissue is removed. The conclusion has been reached that the parathyroids control calcium metabolism, and thereby influence the function not only of the muscle and nerve tissue, but probably of all organs.

The deficiency in blood calcium suggested an associated toxemia, such as has been shown to exist in analagous conditions. Grove and Vines found that in all cases with a lack of calcium, a state of toxemia was present, due to a septic focus somewhere in the body. Their work disclosed that eradication of the septic focus and subsequent detoxication by certain methods augmented the blood calcium content.

Although a new basis for the hyperesthetic or vasomotor diseases is apparent, the rôle of so-called contributory etiologic factors must not be overlooked. These will be discussed in detail in connection with the treatment of seasonal hay fever and asthma.

The Dosage of Thyroid and Parathyroid Substance.—The dosage of glandular substances prescribed in combination with calcium salts is of considerable importance, because no two individuals show the same tolerance for thyroid or parathyroid extracts. Individualization in this connection is best accomplished, first, by studying the metabolic rate, and secondly, by obtaining a most comprehensive report of the physical status of the patient. For this purpose cooperation with an internist may be advisable.

The dosage of thyroid extract has varied in adults from 1/20 to ½ grain, two or three times daily. It is not often that more than ¼ grain doses are required, although their frequency of administration is dependent on the severity of the affection, the tolerance of the indi-

vidual, and the rapidity of the response to the action of the gland substance.

There is no relation between the tolerance and the duration of time in which a patient will respond to any organotherapeutic product. This is easily understood when one knows that some individuals will tolerate thyroid extract in small doses without any untoward reactions over a comparatively long period, while others will promptly show an intolerance to the extract with symptoms of a mild or severe thyroid intoxication.

In children, the same facts hold good. The dosage must be gaged according to existing indications. As little as one one-hundredth of a grain of thyroid substance, two to three times daily, in combination with a calcium salt, has given favorable results.

The dosage of parathyroid substance ranges from 1/50 to 1/10 grain, one to three times daily. As there have been many failures with parathyroid, we have not used it as frequently as the thyroid substance. If a reliable parathyroid preparation is obtainable, it should be prescribed in preference to the thyroid extract, or combined with it for obvious reasons.

Treatment.—For further details of the treatment of Perennial Hay Fever see "Treatment of Seasonal Hay Fever."

CHAPTER XXVII

SEASONAL HAY FEVER

Until very recently, the literature contained meager accounts regarding a constitutional dyscrasia as the underlying etiologic basis for hay fever. Richardson, a few years ago, spoke of a lithemic basis and emphasized the fallacy of local nasal treatment without attention to the constitutional element. Adam, in 1901, asserted that there is much evidence to suggest for hay fever a toxemic basis, kindred to that of asthma, differing probably in the irritant action of certain pollens in the nose and the production of coryza rather than of bronchial spasm. Some also have attributed hay fever to a metabolic disorder, but for some reasons this factor has not been stressed.

Classification of Vasomotor Nasal Diseases.—To clarify the situation, a simple classification is presented. Hay fever is best recognized either as *perennial* or *seasonal.* The perennial type is also known as "all year round" hay fever, pseudo hay fever, vasomotor catarrh, hyperesthetic or vasomotor rhinitis, etc. The seasonal type is commonly designated by the month of the year, or by the particular pollen or flower which is blooming and is believed to produce the excitation. Thus we hear of "spring fever," "rose cold" or "rose fever," "June" or "July cold," "autumnal catarrh" or "fall hay fever." To summarize, perennial hay fever, as its name implies, pre-

vails throughout the year, while the seasonal variety is characterized by its periodicity, depending on the time of the year the individual becomes afflicted.

Symptomatology.—Nasal and conjunctival symptoms are the ones principally complained of. As a rule the patient speaks also of a general depression, mental and physical—second in importance only to the "blocking" of the nose, impaired breathing, violent paroxysms of sneezing and the hydrorrhea. These are identical in both the *perennial* and *seasonal* types, and differ only in the manner in which they are produced. In the "all year round" type, the slightest exposure to cold, as stepping on a cold floor when arising in the morning, is sufficient to provoke violent symptoms and particularly a paroxysm of sneezing. Changing of underclothes in the presence of the slightest draft, the dust raised from sweeping, the use of powders, an automobile ride on a dusty road, burning of certain substances, the odor of gasoline or oils and what not, will produce active hay fever symptoms—the periodicity being of no significance.

In the seasonal type, however, it is recognized that certain grasses or plant pollens act as the external irritants, or, as we have chosen to call them, the extrinsic factors. No classification of these phenomena is attempted, because this has been very ably covered by workers who have spent years on this problem. We have reference to such investigators as Sheppegrel, Selfridge, Koessler and others. A consideration of the intrinsic factor is essential to an understanding of several newly advanced theories concerning the etiology of hay fever and allied affections.

Calcium Content of the Blood.—Seasonal hay fever does not give a low blood calcium content in all cases.

In fact, many blood specimens yielded a normal calcium figure, and some even gave results in excess of the standard. There are factors other than calcium deficiency which must be considered. These will be elaborated later. In Brown and Hunter's series of 32 cases of typical seasonal or pollen hay fever of all types, 28 per cent had a *definite calcium deficiency*. Thirty-four per cent were *low normal* and 38 per cent were *normal*.

Etiology.—We have attempted to systematize the causes of hay fever by a classification which includes (1) the extrinsic factors or external irritants or excitants, (2) the intrinsic cause, (3) the contributory factors.

In the first group are included pollens, animal dander, perfumes, foods and drugs, bacterial proteins and sera. The intrinsic cause or constitutional dyscrasia is a deficiency of blood calcium and an associated toxic state. The contributory etiologic factors involve, among other phenomena, focal infection, nasal, sinus and pharyngeal pathology, and diseased conditions of the gastro-intestinal tract.

The Extrinsic Causes.—Of the many theories which have been advanced, protein and pollen sensitization has found the greatest number of adherents. However, opinions concerning the permanent effects of desensitization are still varied and unsettled.

Successes claimed by some are not substantiated by the results obtained by others in large series of cases. Vander Veer, who treated about 2,000 patients with asthma, hay fever, and allied conditions, was able by means of pollen extracts to entirely relieve 25 per cent of this series. Vaughn, although he considers desensitization a specific treatment for hay fever, agrees that a not inconsiderable proportion of subjects experience

little or no improvement, and a few apparently develop more severe attacks than in the years in which they have received no prophylactic treatment at all.

The other extrinsic factors or excitants, such as foods, drugs, bacterial proteins and sera, involve much the same phenomena as plant pollens. Any one of the excitants undoubtedly is capable of producing allergic symptoms. The manner of introduction, whether by ingestion or inoculation, is not material.

The Intrinsic Cause.—A possible intrinsic cause or constitutional element was suggested by many early writers. Grayson, in 1897, recognized that such a condition was invariably present in hay fever patients. He was not, however, able to demonstrate this constitutional dyscrasia.

In 1893, Bishop announced his uric acid theory and for a time much interest centered around this view. From time to time other theories were advanced. During the past two decades, however, the large majority of physicians have concentrated on desensitization and no other etiologic basis or treatment has met with such general acceptance.

Drug therapy, too, in the hands of different investigators, has given varied results. The successes with calcium administration in hay fever and asthma have been pleasing in many instances. In 1915, Wilson reported favorable results with calcium therapy in a series of hay fever cases. More recently, Schliack, a German author, recorded marked success with calcium, not only in the *cure* of asthma, but more so in its prevention.

The results of Wilson and others have been substantiated in the treatment of hyeresthetic rhinitis.

In this affection local therapy has been replaced by systemic measures. In fact, successes with the latter have been the principal incentive to study this problem in a more detailed manner.

Contributory Etiologic Factors.—Contributory etiologic factors must be adequately considered. The teeth, tonsils, nose and sinuses and gastro-intestinal tract have been found at various times to influence hay-fever and also asthma. That there is a reflex (toxic?) factor involved is agreed upon, especially with reference to the nose and sinuses.

Heatly and Crowe, in their report on a study of sixty-two cases of asthma, concluded that pathological conditions in the nose and accessory sinuses may have an important relation to bronchial asthma. The sinuses most commonly affected were the ethmoids and antra. Obstructive deviation of the septum, hypertrophy of the turbinate membranes, chronic tonsillar infection, and infected adenoids were found in many cases singly and in combination.

Kaiden quite recently emphasized that nasal obstruction was an important factor in the causation of hay fever and allied conditions. According to this author, if a pathological nasal obstruction be present, the physiological reflex swelling of the nasal mucous membrane, following exposure to a sensitive protein or pollen, causes complete interference with nasal discharge; in other words, it produces the picture of hay fever, rose fever, or nasal hydorrhea.

On the other hand, obstruction of both nasal cavities diverts the route of the inspired air to the mouth. This diverts pathological changes in the bronchioles and alveoli, interference with the normal emptying of the

lungs and the resultant symptom-complex—*bronchial asthma.*

The factors produced by irregularities in the upper respiratory tract may have an important bearing on the causation of hay fever and asthma, and while from the standpoint of the rhinologist, these are of paramount interest, one must not lose sight of the influence of gastro-intestinal pathology. Intestinal stasis will produce a toxic state. This status exists in chronic form in most asthmatics. There are undoubtedly many other pathologic conditions involving the abdominal and pelvic organs, which may be looked upon as infective foci. These the diagnostician may find in the course of a thorough physical examination.

Prophylaxis.—The prophylaxis of hay fever, aside from protein desensitization, as, in the past, received little or no attention. Probably certain diseases predispose to hay fever, but nothing definite is known in this regard. It is well recognized that certain occupations and pathological conditions of the upper respiratory tract lead to one or the other of the hyperesthetic diseases.

Much can be accomplished in the prevention of hay fever. The greatest problem has been the recognition of a septic focus. At first this may appear obscure and every means at our command may be necessary to determine it. The infective process may readily be found in the nose, or a chronic appendicitis or gall bladder disease may be the actual etiologic factor. Such states are not always easily or quickly determined, and success is achieved only by exhausting all clinical and laboratory tests.

While the elimination of the septic focus is the first step in detoxication, this is only a small part of the work.

Every system of the body must be called upon to aid in the process. The gastro-intestinal tract carries the heaviest load, next to the skin, and the genito-urinary apparatus and the respiratory system come in for their share. Just which procedures are employed for elimination is of no real importance. We know that the same method will not be adequate for any two cases and drugs, diaphoresis, electrotherapy—each has its part, and all may have to be employed.

Treatment of Perennial and Seasonal Hay Fever.—Unless contraindications have been determined by the various diagnostic measures, the primary aim is to relieve the acute symptoms. In perennial hay fever this is easily accomplished. The patient is placed on a combination calcium and thyroid therapy, by mouth, the dosage depending on the age and severity of the symptoms. As was mentioned in the preceding chapter, the average dose of calcium for the adult is ten grains, and that of thyroid extract, one-quarter to one-half grain.

Beck and Pollock recently reported the results obtained in treating a series of 25 cases of true hyperesthetic rhinitis with general ultraviolet radiations. Most of the cases were from one to five years' duration. The clinical symptoms disappeared completely in all of the patients and only in one did a recurrence appear. "This came on suddenly about six weeks after treatment was discontinued, just as severe as ever. The patient was again placed on the treatment and after twelve exposures, all clinical symptoms cleared up and remain so to the present time." (Beck and Pollock.)

In perennial hay fever or hyperesthetic rhinitis, the rule is to leave the nose alone during the acute stage, and if no definite anatomical defect or influencing local

disease be present, general treatment alone will be found sufficient to abate the symptoms and produce prolonged relief. Operative intervention should be undertaken only after all acute symptoms have subsided.

Seasonal hay fever calls for the same program, save that prophylactic measures are distinctly advantageous and should be employed four to six weeks before the anticipated attacks. Seasonal hay fever requires local measures in addition to the general ones. These include (1) diathermizing of the entire nasal mucosa, followed immediately by (2) ultraviolet radiation intranasally, and (3) quartz lamp raying of the entire body.

The technic employed is similar to that of Sampson, who does not, however, suggest the basis for this therapy. To overcome the obstacles presented by the older diathermy applicators, we have recently devised one which seems to be satisfactory. A mono-terminal, Tesla or Oudin current is administered to the point of tolerance. As it is conducted by a non-vacuum electrode, the first effect is heat. It is a surface heat and undoubtedly serves in two ways—first, it is desensitizing to some degree, and secondly, it prepares the nasal mucosa for more intensive penetration of the ultraviolet rays. The diathermy, too, may have some action on the nerve endings, in that it overcomes reflex phenomena excited from stimulation of certain points in the nose. Diathermy undoubtedly adds to the healthy state of the membrane. Heat is known as one of the most powerful germicides and, as such, tends to keep the surface area fairly free from bacteria. In this way the nasal membrane is kept healthier, rendered more resistant to infection and lessened in sensitiveness.

The technic of ultraviolet irradiations has been

described. We advocate massive doses on a tolerance basis, short of blistering effects. We are quite certain that failures with the water-cooled lamp in nasal work have been due to insufficient and improper raying of the nasal membranes. After the tolerance of a patient has been raised, one may cautiously give a total of ten to fifteen minutes of local treatment. The number of irradiations varies according to the clinical results. It should be noted, however, that there is no fixed rule, the condition of the burner playing an important part in the duration of treatments.

CHAPTER XXVIII

ASTHMA

A specific cause for asthma has never been demonstrated. Writers have advanced all sorts of theories, none of which, however, have stood the test of time. The theory of a neurosis, the acceptance of pollens as primary causes, fascinating as they have been in some respects, vanish under the scrutiny of critical analysis and clinical investigation as untenable hypotheses. The test of any theory of a causative factor of disease is therapy.

In sifting our material for an etiologic study of asthma, we recognize, as in hay fever, extrinsic and intrinsic causative factors. The former are also designated as external irritants or excitants, and include pollens, proteins, dust, fumes, animal emanations, and the like. The latter comprise systemic dyscrasias—*disturbed body metabolism.*

Proteins and Pollens.—In studying the extrinsic causes we are principally interested in the part played by proteins. The consensus of opinion of competent observers is that protein desensitization has not established itself as a specific for asthma.

Major William H. Allen, U. S. Army, tested twelve out of thirty-three asthmatics for protein sensitization toward certain pollens, bacteria, and animal hairs, and found positive reactions, but the therapeutic tests proved negative. The relation of exposures to the offending materials and asthmatic attacks could not be established.

Maxwell saw positive cutaneous reactions in forty-eight out of ninety-seven asthma patients and claims 65 per cent of cures. In other words, the figures are based on a group showing positive skin reactions.

Caulfield was disappointed with the tests in bronchial asthma, and became convinced that there are other causes than sensitization to a specific protein or pollen.

Vander Veer, with an experience of over two thousand cases of hay fever and asthma, doubts the ability to induce permanent immunity with protein therapy.

Allergy and Anaphylaxis.—An understanding of anaphylaxis would do much toward clarifying the situation with reference to the principles underlying certain forms of therapy for hay fever and asthma. It must be admitted that the term *anaphylaxis* has been employed too loosely, and has been associated with various phenomena without sound basic reasons. It is well recognized, for instance, that non-toxic substances, such as egg-white, are able to produce severe symptoms of anaphylaxis, but as Bayliss pointed out, a necessary condition seems to be that of the colloidal state. This latter phenomenon, while known to be essential, is only lately receiving the attention it merits.

Bayliss' account of this subject reviews the work of many prominent authorities including Richet, Besredka and Arthus, and indicates that the value of the many researches consists in the fact that they were made chiefly on an isolated organ. Thus it is contended that in different animals, the actual symptoms characterizing the anaphylactic state vary according to the changes in the blood by which the tissue cells are affected.

Permeability of the cell membrane is a subject closely

interwoven with anaphylactic shock. Calcium salts tend to oppose the reaction, a fact which is explainable by their relation to colloidal processes. Finally anaphylaxis is defined as "the physiological response of an animal in a certain phase of immunity to the artificial test which we impose." (Bayliss.)

Anaphylactic Nature of Hay Fever and Asthma.—In what manner do anaphylaxis and hay fever and asthma appear analogous? This is not a simple question to answer, and an authority like Cooke has definitely evaded it. Animal experiments and clinical observations suggested to Wolf-Eisner (1906) the anaphylactic nature of hay fever, and, in 1910, Meltzer first considered bronchial asthma from the same point of view. There has since accumulated an abundance of evidence to corroborate this opinion. Analysis of available reports makes possible a division of proofs into four classes (as suggested by Cooke) viz.: *analogical, experimental, clinical,* and *therapeutic.*

The *analogical* proofs include the production of bronchial spasm and eosinophilia in guinea pigs after artificial sensitization. The *experimental* proof is based on the occurrence of hay fever and asthma in man following hypodermic injection of pollen extracts, while the *clinical* proof is demonstrated by the hypersensitiveness of hay fever and asthma sufferers, as shown by intracutaneous tests with animal or vegetable foods or emanations. *Therapeutically,* proof is apparent by the permanent or temporary relief obtained from injections of various protein substances.

There is, however, an overwhelming number of reported cases which render difficult the division of bronchial asthma and hay fever into allergic and anaphylactic phe-

nomena. The group of vasomotor respiratory diseases referred to as hyperesthetic rhinitis or perennial hay fever, does not fit into the above classification.

Hypersensitivity to the many experimental proteins has been found wanting, and non-specific therapy has been of little avail. Yet the diseases manifest themselves as typical allergic conditions, so that one must agree to a more profound and fundamental conception of anaphylaxis and allergy, especially as regards their genesis. Studies to this effect have been carried on for a long time and a review of these observations and deductions is enlightening.

Characteristics of Anaphylaxis.—Hanzlik has described the characteristics of anaphylaxis in detail. We quote the more important of these, which emphasize the main points in which we are interested:

1. Native or complex proteins in colloidal suspension only can produce true anaphylaxis, administered orally or parenterally (after a period of sensitization).

2. Hyperexcitability of excised or isolated smooth muscle tissues shows that the seat of reaction is peripheral and localized in the tissue.
Krehbiel, and Bernard).

3. Important physical and chemical changes are demonstrable in the blood, plasma and lymph. Among the physical changes produced may be enumerated: (a) surface tension is lowered; (b) viscosity of the blood is increased; (c) resistance of erythrocytes to hypertonic solutions, and (d) colloidal behavior of globulin is altered. Among the important chemical changes are progressive acidosis and quantitative increase of animo acids. There are also disturbances in nitrogen equilibrium, total solids, blood sugar and PH values (as reported by Rohdenburg,

4. No anaphylactic poisons have been isolated, except histamin and peptone.

5. Animal fatalities are due to tissue asphyxia in consequence of flocculation, edema and capillary embolism, which obstruct the capillary net work.

Characteristics of Anaphylactoid Phenomena.—A variety of substances, not related physically or chemically, can produce allergic manifestations. The fact that calcium salts do not produce anaphylactoid phenomena is of great importance. On the other hand calcium salts prevent or inhibit experimental edema and clinical allergic manifestations, owing, presumably, to their power to lessen cellular permeability, indicating indirectly the possible physical basis for the reactions produced by many agents. Flocculation, agglutination of platelets, disturbance of viscosity, and all possible physical and chemical changes in the blood take place. The period of incubation is not uniform. We know that many substances enhance the allergic phenomena merely by their catalytic properties, and that drugs may have both depressing and stimulating actions on the same organ, depending upon the physico-chemical mechanisms in the blood and peripheral tissues. The precise nature and operation is of course unsettled, but there appears little doubt that a multitude of varied and unallied agents, protein and nonprotein, produce the same changes in cell surface tension, osmotic pressure, and in the electrical potential of cells.

Calcium in Relation to Asthma.—Calcium salts do not produce anaphylactoid phenomena, but prevent or inhibit experimental edema and clinical allergic manifestations. The explanation is to be sought in the ability of these salts to lessen cellular permeability.

We have investigated whether calcium salts, in small or

large doses, taken orally, or administered intravenously, will produce a localized action on the mucous membranes of the upper respiratory tract in hypersensitive individuals. We are prepared to assert that undoubtedly a surface action in the nose is produced. The mucous membranes of the nose change in color from an anemic, bluish hue to a normal pink, after a comparatively short period of calcium administration. It is interesting to note, however, that unless the calcium therapy is supplemented by other agents, this change is not permanent. It is also of great interest to note that while calcium, as has been stated by some writers, when applied topically, is depressant to the peripheral nerve endings in the nose, no such effect is apparent when calcium salts are administered internally.

We are also of the opinion that there are other factors which influence calcium action. From data obtained from metabolic experiments, Telfer concluded: (a) that absorption of calcium is initially dependent on the free acid of the gastric juice, which plays an important part in effecting the solution of calcium salts in the diet; (b) that absorption is normally restricted by the alkaline reaction of the intestinal secretions which tend to neutralize and so cause precipitation of the lime in solution as insoluble phosphate; (c) that the free absorption of calcium may be limited chiefly to a comparatively small portion of the upper part of the intestinal tract while still in acid solution. To insure adequate absorption, considerable excess of calcium in the diet is necessary.

Local and General Anaphylaxis.—According to Coca, all of the local phenomena of specific hypersensitiveness, whether these were caused by antigenic or non-antigenic

substances, have been designated as local anaphylactic reactions. Thus, by some authorities, a form of local anaphylaxis is recognized to exist, and may occur actively or passively. In hay fever this local hypersensitiveness is actively manifest in the mucous membranes of the upper respiratory tract and in the conjunctiva, although occasionally symptomatic evidence of involvement of the whole respiratory tract, as in asthma, is quite obvious.

Animal experiments have demonstrated that desensitization will favorably influence local anaphylactic reaction, while the systemic response to this method is a recognized occurrence. It is logical to assume that desensitization to overcome a systemic reaction will at the same time overcome any local reaction which may exist. This has been demonstrated in man in at least several presumably associated anaphylactic states, particularly in urticaria, certain types of the eczemas and in what is commonly known as reflex asthma.

What means have we to control the situation? It is necessary to distinguish *non-specific* and *specific* forms of the phenomenon, but the details in connection with these we omit at this time. Suffice it to say that in the non-specific form of anti-anaphylaxis, by means of certain physical agents, which will be described, we are able to produce a type of local, as well as general desensitization, although this latter phenomenon is clearly classified as one of the means of specific anti-anaphylaxis. It is quite obvious that the terminology is confusing, for one must understand the scope of desensitization, lest it be too narrowly applied.

Blood Chemistry Studies.—It will be recalled that in the original report published in the *Journal of the American Medical Association* in 1923, Novak and Hollender

called attention to the fact that bronchial asthma presents a calcium deficiency in a certain percentage of cases. Since that time, many investigations have been conducted. Brown and Hunter tested 100 patients with asthma for calcium. Of these 42 per cent had a definite calcium deficiency, 23 per cent were low normal and 35 per cent were normal. In this group were included both asthmatic bronchitis and true bronchial asthma.

Brown and Hunter's work is suggestive of a definite calcium deficiency in asthma, since 65 per cent of their series showed a true calcium deficiency and a low normal. Of a total number of 166 consecutive patients [1] upon whom calcium determinations were made, 39 per cent had a definite calcium deficiency, 24 per cent were low normal and 37 per cent were normal. As these writers pointed out, variations in calcium determinations by different laboratory technicians must be allowed for; therefore the establishment of a definite calcium norm for the individual technic is of fundamental importance.

Ramirez, St. George and Moses submitted a series of chemical findings obtained during the routine examination and treatment of forty patients with asthma, hay fever, and allied conditions. Non-protein nitrogen, sugar and plasma chlorid were determined, both before instituting treatment and after its completion. Uric acid and creatinin determinations were discarded, as the figures permitted no interpretation. Determination of the mineral constituents of the blood was attempted only recently, and a series large enough for publication has not yet been collected; however, the calcium content of the blood in true bronchial asthma and in bronchospasm,

[1] This series was made up of perennial and seasonal hay fever, and asthma, and not asthma only.

promises to be of special interest. In asthma, urticaria, hay fever, etc., there appears to be a relative high chlorid content of the blood and to a less extent of the sugar and non-protein nitrogen, the latter two especially in the non-allergic type of asthma cases, with a long standing associated bronchitis. Some diminution in the constituents occurs after treatment, but it is impossible definitely to state that treatment caused a marked change in the chemical constituents of the blood.

Bronchial asthma is accepted as the result of anaphylaxis and dependent upon the sensitization of the body to a foreign protein. The clinical experience in some cases of asthma which improved after the removal of nasal infection and mechanical irritation and the removal of infected tonsils, confirms the relation of foci of infection to tissue sensitization.

Tissue sensitization, therefore, is dependent, in some degree at least, on a general toxicosis, the focus of which may be either in the upper respiratory tract or elsewhere in the body. The calcium deficiency indicates that such a toxic state exists and that the body metabolism in general is disturbed. As has been stated, other factors suggesting irregularities in body metabolism besides a blood calcium deficit, exist.

The Endocrines.—The influence of certain endocrines on body metabolism, and in particular, calcium metabolism, must not be overlooked. Various references have been made which allude to calcium fixation in the blood depending on the concomitant administration of parathyroid. Our original investigations in treating hay-fever and asthma have taught us that thyroid extract is a potent adjuvant to calcium therapy in these conditions. Theoretically, parathyroid should prove effective, but

practically it does not, possibly because of the inability of pharmaceutical houses to produce a reliable parathyroid product.

In this connection a recent report on the effect of thyroidectomy on blood serum calcium is of great interest. In 114 consecutive thyroidectomies reviewed by Rabinowitch, there were two cases of tetany. In both cases the symptoms were relieved with calcium salts and the patients ultimately recovered, requiring no further medication. The interesting part of the observation was that no parathyroid tissue was found in the portion of thyroid removed in either case, and in both cases the calcium content of the blood serum was lowered. It appeared reasonable to Rabinowitch to assume that in each of these cases the tetany was not due to the removal, but to trauma of the parathyroid glands from manipulation or temporary interference with the blood supply.

That thyroid (or parathyroid) has a definite action on metabolism, has, we believe, been fairly well established also clinically. The twofold function of the parathyroids, detoxication and regulation of calcium metabolism, strengthens this view. It is certain that in hay fever and asthma, thyroid substance aids calcium absorption and retention, and, accordingly, presents a selective therapeutic action for at least this one mineral constituent of the blood, and probably also for some others.

The Treatment of Hay Fever and Asthma.—The administration of calcium salts alone in either hay-fever or asthma may be of value in some instances, but, in general, it is without permanent results. There are many factors which must be taken into account in addition to medication. These are: (1) physical status of the

patient; (2) special clinical and roentgenologic state of the nose and nasal accessory sinuses; (3) septic foci in the head, chest or abdomen; (4) blood, tissue and urinary changes; (5) concurrent diseases; (6) influence of acute or chronic diseases in the past; (7) mode of living; (8) occupation and environment; (9) habits.

Furthermore, for the purpose of diagnosis, certain standard tests are essential, as these influence the course of treatment, which must be individualized. The tests referred to are: (1) basal metabolic rate; (2) blood chemistry with special reference to the mineral constituents of the blood; (3) complete quantitative and qualitative urinalysis, emphasizing degree of acidity or alkalinity; (4) complement fixation tests for suspected diseases, such as tuberculosis and syphilis.

Use of Physical Agents.—In asthma, as in seasonal hay-fever, local measures are necessary. Strict attention should be paid to all contributory etiologic factors. The initial examination and regulation of metabolic irregularities should be undertaken only when a patient is hospitalized. The benefits of close observation, regulation of diet and systematic detoxication by hospital methods cannot be overestimated. Here, too, individualization in the treatment is essential to success.

Topical raying with quartz light is always supplemented with the tonic sedative effects of general irradiations. Aside from the empiric value of such a measure, there is a definite basis in hay-fever and asthma for ultraviolet therapy. Suffice it to say that the combination of measures serves better than any one, singly. The indications are best explained by the action of ultraviolet rays on body metabolism, and particularly on calcium metabolism.

TABLE SUGGESTING TIME OF TREATMENTS WITH AIR-COOLED QUARTZ LAMP AT A TARGET SKIN DISTANCE OF 30 INCHES

1st treatment 3 min.	2nd treatment 4 min.	3rd treatment 5 min.	4th treatment 6 min.	5th treatment 8 min.
6th treatment 10 min.	7th treatment 12 min.	8th treatment 15 min.	9th treatment 18 min.	10th treatment 20 min.
	11th treatment 20 min.	12th treatment 20 min.		

Principles Underlying the Action of Physical Agents.—Experimentally, it has been shown that animals, actively or passively sensitized, can be protected against a lethal dose of an anaphylactogen, if these animals are subjected to an initial dose of a foreign protein, such as peptone. This state can likewise be produced in the human and has definite clinical application. The foreign protein effect in an asthmatic can be produced by a vigorous dose of ultraviolet radiation, after which, the autosensitizing agents (foci of infection) can be radically removed or corrected. With physical agents, local changes sometimes require local in addition to general measures so that, for example, diathermizing of the nasal membranes with subsequent ultraviolet irradiations are definitely in keeping with the principles involved.

Furthermore, as has been quoted, calcium salts tend to avoid the reaction of anaphylactic shock. And as general irradiations with the mercury quartz lamp are known to augment the calcium content of the blood in hay fever, hyperesthetic rhinitis and the asthmas, this form of therapy is properly indicated.

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APPENDIX

EXPERIMENTAL WORK

APPENDIX

COMPARATIVE STUDIES OF HEAT PRODUCING AGENTS

Diathermis Studies on the Eye and Ear

The purpose of these experiments was to establish the relative penetration values of the heat producing agents commonly used on eyes and ears. Hot wet dressings, lamps of various sorts, and diathermy were studied to determine the comparative value of conductive, convective and conversive heat. The tolerance of the skin and the subcutaneous tissues for heat and diathermy were determined clinically and the limits noted were used as guides for animal experimentation.

Eye Experiments.—Anesthetized dogs were used for the following experiments:

1. Through an incision 1 cm. lateral to the external canthus a pocket was made to the fundus of the orbit by blunt scissor dissection and an electrical, or mercurial, thermometer deeply inserted and fixed with ligatures, etc.
2. Thru another similar skin incision the equator of the globe was exposed and a small incision made in the sclera. Thru this a heat indicator was thrust into the vitreous and adequately anchored.
3. A thermometer was placed into the conjunctival sac and the lids sewed over it.
4. A thermometer was placed on the surface of the lids.
5. A thermometer was placed in the rectum.

The various heat producing agents were applied and the temperatures noted at the start and at regular intervals.

Wet dressings were kept hot by frequent changing and by combining their use with a carbon filament lamp. The "infra-red" lamp was used at a distance of three feet from the part. Diathermy was administered by applying a small well soaped metal electrode over the closed lids (previously shaved) and a larger metal electrode on the under side of

the opposite jaw which was previously shaved. The current was always turned on and gradually increased, and allowed to flow for ten minutes before temperatures were taken.

Each table below gives only the important figures in an experiment and is, therefore, only a condensation of a complete study. All figures given in a table were recorded in a single experiment on the same dog, with the same thermometers and under the same circumstances:

EYE EXPERIMENT No. 1

Time	Start	Diathermy High Voltage 400 ma. Temps. Measured Outside of Line of Current After 10 Minutes		Carbon Filament Lamp at 12 Inches and Hot Wet Dressing at 136° F. After 10 Minutes
Under lid..	96.	112.	S	108.5
In Vitreous	97.5	110.	T	105.0
In Orbit...	98.2	105.	O	101.0
Rectal.....	98.8	100.5	P	99.4
Surface....	90.	111.6		134.6

EYE EXPERIMENT No. 2

Time	Start	Incandescent Lamp After 8 Minutes		Diathermy Low Voltage 250 ma. Temperatures Measured in Line of Current After 10 Minutes
Under lids.	94.	107.	S	104.7
In Vitreous	94.5	102.5	T	103.0
In Orbit...	96.5	99.5	O	102.4
Rectal.....	97.5	98.7	P	99.5
Surface....	84.2	125.6		100.0

Ear Experiment.—A similar study was undertaken on the mastoid region:

1. The skin behind one ear was shaved and a metal electrode 1″ by 1″ applied firmly.
2. The skin in front of the other ear was similarly prepared and a larger metal electrode 1½″ x 3½″ fastened to it.
3. A mid-line incision was made through the skin of the top of the head and a small pocket under the skin was produced by blunt dissection to reach as far as the small electrode.
4. A similar pocket was also made under the thick muscle which lies beneath the skin.
5. Into these pockets thermometers were placed and fastened.
6. A trephine opening was then made and a thermometer placed in the brain substance.
7. A fourth thermometer was introduced between the skull and the dura near the small electrode.
8. Rectal temperature was also taken.

When diathermy was not used the electrodes were removed but nothing else was disturbed.

EAR EXPERIMENT No. 1

Time	Diathermy High Voltage After 10 min.	Diathermy Low Voltage After 10 min.	Infra Red After 5 min.	Infra Red 5 min. later
Under skin.....	108.2	108.2	108.6	114.5
Under muscle...	104.2	105.	101.	102.2
In brain.....	101.2	102.	100.6	101.5
Rectal.....	98.8	99.9	100.4	100.8
Surface.....	110.0	110.0	121.	134.

The most obvious deduction from these experiments is that diathermy generates heat in deep tissues with less heat on the surface of the skin as compared with lamps and hot dressings. The important fact is that to obtain a substantial rise in temperature in deeper tissues with all agents excepting diathermy, the skin temperature must be raised to a degree practically beyond human endurance. It is also to be noted that

the heat with diathermy is localized in the eye region and the temperature is always under immediate control, whereas with lamps the whole head is heated and the temperature can be changed by moving the lamp or the head.

DEEP EFFECTS OF DIATHERMY WITH SPECIAL REFERENCE TO THE TEMPORAL BONE

The object of this study was to estimate the heat generation effect of diathermy in the mastoid region on living and dead tissue, and also to estimate the comparative efficiency of two methods of administration, namely, by way of the auditory canals and by way of the mastoid region.

Experiment No. 1

Electrodes were placed in the external auditory meatus of a dog, after most of the pinnæ had been removed. By means of a thermometer, placed beneath the skin under the electrodes, another under the muscle and one under the skull in as close proximity to the electrode as possible, the temperature was determined, after passing a diathermy current of 400-500 miliamperes for 5 to 10 minutes. The result was as follows: An increase in temperature under the skin, but only a very slight rise under the bone and under the muscle.

Experiment No. 2

A mesh electrode was placed on the shaven skin just behind the ear, and a larger (indifferent) electrode on the shaven jaw of the opposite side. A thermometer was introduced into the middle ear, through the drum membrane. With 400 miliamperes D'Arsonval current a rise in temperature of two to three degrees was noted within 5 minutes.

Experiment Nos. 3a, 3b

With the electrodes as in No. 2, a thermometer was placed under the skin, another between the muscle and skull, and still another beneath the skull on the dura. A fourth thermometer was inserted into the brain substance and a fifth into the rectum. The tables give the results of these experiments.

Experiment 3c

Experiments 3a and 3b repeated on a dead animal.

EAR EXPERIMENT No. 3a

Time	D'Arsonval Current 500		750		Stop Animal Still Alive 20 min. Later
	Start	5 min.	10 min.	5 min.	
Under skin...	95.	98.7	100.6	101.8	94.6
Under muscle	98.7	104.6	104.2	106.	99.
Under bone..	98.3	100.	100.6	101.2	99.
In brain.....	100.	100.	100.	100.2	100.
Rectal.....	100.	100.8	100.8	100.	100.8

EAR EXPERIMENT No. 3b

Time	D'Arsonval Current 500			750		Stop Animal Killed	
	Start	5 min.	10 min.	5 min.	10 min.	5 min. later	15 min. later
Under skin...	92.	95.	96.	102.	100.	92.	90.
Under muscle	97.5	100.8	102.	106.2	107.	105.	103.
Under bone..	97.5	98.5	99.	100.	101.5	101.5	101.8
In brain.....	98.8	99.2	99.3	100.4	101.	101.5	101.3
Rectal.....	98.8	98.8	98.8	98.8	98.8	98.8	97.0
Electrode....	95.	97.	99.5	99.5	99.5	95.	93.2

EAR EXPERIMENT No. 3c (Animal Dead)

Time	D'Arsonval Current 15 min. later	500 5 min.	750 10 min.	Stop 5 min. later
Under skin.....	90.	103.5	109.8	100.
Under muscle...	103.	110.	113.0	112.5
Under bone.....	101.8	103.5	105.5	106.2
In brain.....	101.3	103.0	104.5	104.8
Rectal.....	97.0	97.		
Electrode.....	93.2	114.8	117.0	

From the standpoint of clinical application these experiments are significant because they lead to several definite conclusions:

1. Diathermy introduced by way of the ear canals does not reach with adequate intensity the middle and inner ears.
2. Diathermy introduced by an active electrode behind the external ear, with the indifferent electrode anterior to the ear on the opposite side produces a substantial rise in temperature in the region of the ear from the middle ear to the inner surface of the skull.
3. With diathermy the maximum temperature is reached only after ten minutes' application.
4. With D'Arsonval currents of 300-500 miliamperes there is practically no effect on the brain nor on body temperature.
5. The highest temperature obtained was between the muscle and bone, where the increase was usually greatest.
6. In living tissue there is a return to normal temperature within twenty minutes; in dead tissue the change is much more gradual (up to two hours).
7. Under the very same conditions, a D'Arsonval current produces higher temperatures in dead than in living tissues.

RELATIVE HEAT VALUES OF LOW, MEDIUM AND HIGH FREQUENCY CURRENTS OF LOW AND HIGH VOLTAGE

This study was undertaken to determine the temperature of deeper tissues produced by diathermy currents of high and low voltage and of different frequencies of oscillation.

The apparatus used was specially prepared for this investigation by the H. G. Fischer Company of Chicago. Provision was made for a change of voltage from 600 to 50,000. A special arrangement made possible a gradual change of the frequency of oscillation from 1½ millions to 2½ millions per second.

The animal was prepared for this experiment in exactly the same manner as for experiments 3a, 3b and 3c of the preceding study. (See also Archives of Otolaryngology, Vol. 3, pp. 338-348, April, 1926.)

The table following gives the temperatures produced by high

Voltage	Low Frequency—(About 1 Million)							
	Experiment 1		Experiment 2		Experiment 3		Experiment 4	
	High	Low	High	Low	Low	High	Low	High
Under skin	102.	104.6	108.2	108.2	99.2	99.	99.5	100.8
Under muscle	98.4	101.2	104.2	105.	98.	97.2	97.5	98.2
In brain	98.4	99.4	101.2	10.2	97.5	97.3	97.5	98.1
Rectal	97.2	98.	98.8	99.9	96.8	96.5	96.8	96.8
Difference between skin and muscle temperature	3.6	3.4	4.0	3.2	1.2	1.8	2.0	2.6

Voltage	Higher Frequency—About 2½ Million Experiment 5		High Frequency—About 3½ Million Experiment 6	
	High	Low	High	Low
Under skin	128.	122.5	105.5	103.6
Under muscle	121.	117.	98.8	98.6
In brain	92.4	102.2	97.6	97.5
Rectum	98.6	99.	97.0	96.9
Difference between skin and muscle	7.0	5.5	6.7	5.0

and low voltage currents, with the amperage the same for both voltages. The amperage, however, was different in each experiment.

The most significant figures are those showing the difference in temperature between the skin and muscle, because these indicate the penetration of heat. In other words, the more nearly the muscle temperature approaches the skin temperature, the greater the efficiency of the system to heat deep tissues.

From these experiments we draw the following important conclusions:

1. Low voltage currents are more effective in producing deep heat than high voltage currents, if the frequency and amperage are constant. (Experiments 1 to 3c.)
2. Low frequency currents are more effective than high frequency currents for producing deep heat if the voltage and amperage are constant. (Compare Experiments 1 and 3c.)
3. High voltage and high frequency currents produce greater superficial heat effects than low voltage and low frequency currents, if the amperage is the same. (Experiments 1 to 3c.)

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